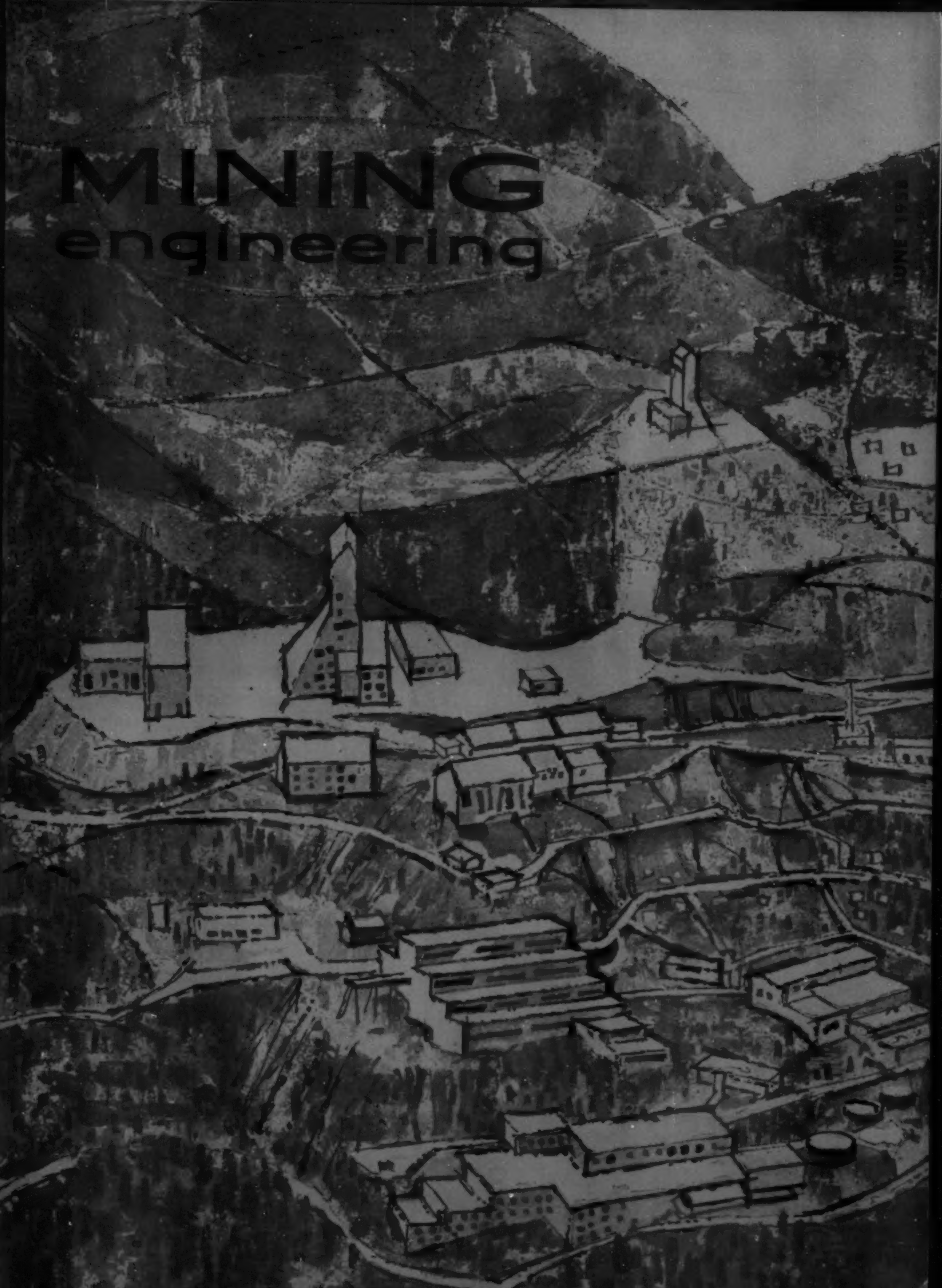
MINING engineering

JUNE 1958



Coming Events

June 13, AIME Reno Subsection, Nevada Room, Hotel Mapes, Reno, Nev.

June 13-14, AIME Central Appalachian Section and SME Coal Division, joint meeting, Phoenix Hotel, Lexington, Ky.

June 22-25, Annual Convention of the Mine Inspectors' Inst. of America, Shirley-Savoy Hotel, Denver.

June 26, AIME Pennsylvania-Anthracite Section, summer meeting, Split Rock Lodge, White Haven, Pa.

June 28, AIME Adirondack Section, Gouverneur area zinc-talc operations trip, golf, Gouverneur, N. Y.

June 29-July 2, Rocky Mountain Coal Mining Inst., annual meeting, Hotel Colorado, Glenwood Springs, Colo.

July 3-5, Mining Soc. of Nova Scotia, annual meeting, Keltic Lodge, Ingonish, N.S., Canada.

July 26, AIME Adirondack Section, weekend with wives, Ottawa.

Aug. 23, AIME Adirondack Section, golf and speaker, Tupper Lake, N. Y.

Sept. 17-19, AIME Rocky Mountain Minerals Conference, Newhouse Hotel, Salt Lake City.

Sept. 18-20, Rocky Mountain Assn. of Geologists, symposium on Pennsylvanian rocks of Colorado and field trip, Maroon Basin, northwest Colorado.

Sept. 22-25, American Mining Congress Mining Show, Civic Auditorium, San Francisco.

Sept. 27, AIME Adirondack Section, National Lead trip, Tahawus, N. Y.

Oct. 2-4, Annual Drilling Symposium, University of Minnesota, Minneapolis.

Oct. 9-10, AIME-ASME Solid Fuels Conference, Hotel Chamberlin, Old Point Comfort, Va.

Oct. 13-16, Soc. of Exploration Geophysicists, annual meeting, Gunter Hotel, San Antonio, Texas.

Oct. 15-17, Energy Resources Conference, Brown Palace Hotel, Denver.

Oct. 16, AIME Utah Section, speaker: L. V. Olson; subject: Progress in Air Pollution Control; Salt Lake City.

Oct. 20-23, National Clay Conference, Natural History Bldg., Smithsonian Inst., Washington, D. C.

Oct. 23-25, AIME Mid-America Minerals Conference, Chase-Park Plaza Hotels, St. Louis.

Oct. 24, AIME Lehigh Valley Section, trip to Niki Installation, Doylestown, Pa.

Nov. 7, AIME Pittsburgh Section and AIME NOHC Pittsburgh Section, 13th annual Off-the-Record Meeting, Penn-Sheraton Hotel, Pittsburgh.

Nov. 13-14, Missouri School of Mines and Metallurgy, 4th annual symposium on mining research, University of Missouri, Rolla, Mo.

Dec. 1, AIME Arizona Section, annual meeting, Pioneer Hotel, Tucson, Ariz.

Dec. 5, AIME Lehigh Valley Section, ladies' night, Lehigh Valley Club, Allentown, Pa.

Dec. 11, AIME Utah Section, panel discussion on Place of Research in the Minerals Industries; members: chairman J. M. Ehrhorn, S. R. Zimmerley, J. B. Clemmer, W. M. Fassell, Jr., J. R. Lewis; Salt Lake City.

Feb. 15-19 1959, AIME Annual Meeting, Sheraton-Palace, St. Francis, Sir Francis Drake Hotels, San Francisco.

Apr. 5-10, EJC 1959 Nuclear Congress, Public Auditorium, Cleveland.

MINING engineering

VOL. 10 NO. 6 — JUNE 1958

COVER

The Jackling Lecture is a major feature of the Annual Meeting. This year's lecturer, A. H. Shoemaker, discussed *Planning Deep Mining at Homestake* and artist Herb McClure has chosen to depict the famous South Dakota mining company on this month's cover. Text of the lecture begins on page 685.

ARTICLES

A Panel Discussion:
Mineral Engineering Education—Its Challenge and Its Future 669

Economic Evaluation of an Industrial Mineral Project J. E. Castle 675

Mesabi of the North 678

Canadian Iron Ore P. E. Cavanagh 680

TRANSACTIONS

1958 Jackling Lecture
Planning Deep Mining at Homestake A. H. Shoemaker 685

Relative Effectiveness of Sodium Silicates of Different Silica-Soda Ratios as Gangue Depressants in Nonmetallic Flotation C. L. Sollenberger and R. B. Greenwalt 691

Effect of Chemical Reagents on the Motion of Single Air Bubbles in Water D. W. Fuerstenau and C. H. Wayman 694

Technical Note: Study of Thorium and Uranium Minerals by X-Ray Microscopy S. Yamaguchi 689

Discussion 699

FEATURES

Personnel	638	**AIME News**	712
Books	640	**Around the Sections**	714
Manufacturers News	651	**Personals**	717
Reporter	655	**Obituaries**	726
Trends	661	**Professional Services**	728
SME Bulletin Board	701	**Advertisers Index**	732

Drift: Education and the Challenge of Mineral Engineering R. Beals 667

Published monthly by the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 29 West 39th St., New York 18, N. Y Telephone: PEnnsylvania 6-9220. Subscription $8 per year for non-AIME members in the U. S., & North, South, & Central America; $10 foreign; $6 for AIME members, or $4 additional for members only in combination with a subscription to "Journal of Metals" or "Journal of Petroleum Technology". Single copies, $.75; single copies foreign, $1.00; special issues, $1.50. The AIME is not responsible for any statement made or opinion expressed in its publications.

Registered cable address, AIME, New York. Indexed in Engineering Index, Industrial Arts Index, and by The National Research Bureau. Second class mail privileges authorized at New York, N. Y., and additional entry established at Manchester, N. H Number of copies of this issue 15,100.

PERSONNEL

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc. (Agency) operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

—MEN AVAILABLE—

Geologist, B.S. in geologic engineering, age 36. Eight years exploration geologist, including property evaluation and program management, mostly uranium. Single status. Prefer foreign assignments. M-417.

Mining Engineer, B.S. in mining engineering, age 24. Two years experience includes uranium mining, copper mining, construction foreman. Presently serving in armed forces, Seoul, Korea; discharge date July 1958. Location, immaterial. M-418.

Mining Engineer, B.S. in mining, age 29. Underground production base metals 3½ years. Good Spanish, excellent health, single with pilot's license (self). Desire location in Caribbean but will consider other Latin American or Gulf area. Available 30 days. M-419.

Supervisor or Engineer, age 39, with supervisory experience all phases of small operations, both producing and under exploration. Also have done engineering design for large mining company and surveying of large areas in connection with aerial photographic mapping. Prefer southwest United States. M-1033-SF.

Metallurgist, B.S. in chemistry (34 hr graduate work), age 39. Experienced research, plant development, plant design, plant control, and engineering report writing. Ten years experience flotation, hydraulic sizing, crushing, drying, calcining, magnetic and electrostatic processing of nonmetallic ores. M-420.

Manager or Superintendent, B.S. in mining engineering, age 42. Eighteen years experience metallics and nonmetallics covering mine examination, exploration, development, open pit production supervision. Three years project engineering, industrial engineering, and plant supervision. Desire position as manager or superintendent small to medium sized mining and/or processing operation, prefer nonmetallics. Location desired, U. S., preferably west. Available immediately. M-421.

Mining Engineer, B.S. in mining engineering, age 25. Experienced as assistant engineer with large Pb-Zn mine; two years scholarship work program with gold placer operation (12 months or 3 summers). Prefer U. S. or foreign. M-1276-SF.

Mining Engineer, B.S. in mining engineering, age 30. Experience: 5½ years open pit engineering, all phases; ½ year underground mining. Prefer western U. S. M-1319-SF.

Mineral Economist, M.S., age 27. Two summers underground at Franklin, N. J.; two summers quarry work, graduate assistant Dept. of Mineral Economics, Pennsylvania State University. Prefer New York or Philadelphia area. M-422.

Exploration and Mining Geologist, now in Australia, offers knowledge and experience to companies or persons engaged in finding and/or mining minerals, especially under rugged conditions. M-423.

—POSITIONS OPEN—

Mining Engineer, with gravity milling experience, to take charge of an open-cut manganese mine and mill employing 20 to 30 men. Salary, open. Location, south. W6048.

Mining Engineer, registered, for civil engineering work in conjunction with new central cleaning plant for coal mining, 15,000 tpd. Upon completion of plant would be transferred back to mines as chief of the engineering department for two new mines now in development stage; mines will be 5000 tpd, full mechanized operation. Salary, $7,800 a year to start; when transferred to mine, $10,800 a year to start. Location, south. W6024.

Safety Director, to organize safety program for uranium mining and milling operation of about 500 employees. Should have underground mining experience. Salary, open. Location, southwest. W6016.

Paleontologists/Micropaleontologists, to 35, minimum bachelor's degree in geology, master's degree preferred, with at least one year in petroleum paleontology. Duties will include paleontological/micropaleontological laboratory and some field work involving examination of outcrop and well samples. Salary, to $11,400 year; allowances: single status, free board and lodging plus equivalent of U. S. $54 monthly; married status, equivalent of U. S. $462 monthly after wife joins husband in field. If married, approximately six months separation. Location, Far East. F6003.

Mine Superintendent, coal mine operations, to take responsible charge of design, construction, mine development, maintenance, and op-

(Continued on page 640)

"Not merely to sell; but to serve . . . not only to make good steel products; but to make them still better . . . not only to fulfill today's requirements; but to anticipate tomorrow's—these are the principles that constantly guide CF&I."

President

Grinding Mill Bulletin #2

This ad is directed to those grinding mill operators who are interested in increasing the efficiency and production capacity of their ball mills. It is presented by CF&I—in line with our policy "*not merely to sell; but to serve*"—in the hopes that it will add some new information on grinding procedures.

First Things First—Determine Best One Size Ball Makeup Charge

In the first article of this series, it was shown that determining the optimum size assortment of grinding balls for a makeup charge is a practical means of improving mill operation. Before an attempt is made, however, to work out a ration makeup charge, the best makeup charge of one size ball should be established.

Factors Determining Correct Ball Size Choice

Ball . . . 1) Specific Gravity (affected by voids in the ball); . . . 2) Shape; . . . 3) Homogeneity; . . . 4) Relative Cost of balls by diameter

Mill . . . 1) Inside Diameter; . . . 2) Speed (peripheral speed rather than percent of critical speed)

Manner of Operation (assuming one-stage grinding only) . . . 1) Open or Closed Circuit (percent circulating load of closed circuit); . . . 2) Mill Pulp Density (specific gravity of pulp constituents)

Feed Material . . . 1) Size Structure of Mill Feed; . . . 2) Desired Particle Reduction; . . . 3) Character of Ore, i.e. (a) Specific gravity of gangue and of mineral or minerals, and (b) Grindability characteristics (comminution to crystal sizes; comminution through crystal sizes; sliming characteristics)

Ball Makeup Charge of One Size, for a New Mill

Use all the tools at hand to determine the best one size ball makeup charge: laboratory tests of feed material, mathematical formulae, and recommendations from ball mill and grinding ball manufacturers. One's own experience, of course, is invaluable. Full confidence cannot be placed in mathematical formulae for they may not accurately take into account all the factors affecting the not-fully-understood, complex mechanics of ball mill grinding. Tests made with laboratory-size equipment can indicate grindability of ore, but such scale-size work has its limitations in that the ratio between mill diameter, mill peripheral speed, ball diameter and particle size obtained in laboratory is not the ratio that exists in the full-scale operation.

Character of Ore—So IMPORTANT!

When a new mining property is being developed, the ore body is often not accessible; so that sampling will not indicate all the types of ore that will eventually be encountered. It is important that the comminution problem of the various ores to be encountered be studied in terms of the subsequent metallurgical processes, both physical and chemical. The degree to which the ores will be blended before entering the ball mill should be taken into consideration.

If no blending or poor blending is anticipated, the most difficult grinding ore should be given the most weight in determining ball size, although this size may be too large for the softer ores.

Effect of Ball Size

Either too large or too small a ball size addition will result in decreased mill throughput and increased power consumption per ton of ore ground for ball mill operations in closed circuit. Under-size balls haven't the impact to break the larger particles effectively, adversely affecting subsequent mineral liberation. Over-size grinding ball addition results in the seasoned charge of fewer balls offering less surface for attrition grinding, thus giving too coarse a grind for efficient mineral liberation. The optimum one size ball addition is a "happy medium" between these two conditions.

The penalty for the use of too small a size ball addition is generally considered greater than for using too large a size ball, so the tendency is to favor the larger size.

CF&I grinding balls are available in diameters from ¾" to 5", and are forged from special analysis steel. They are carefully inspected throughout production and immediately before shipment to make certain they have no surface pits, circumferential ridges or other surface unevenness. They are specified by many leading mill operators. Your nearest CF&I sales representative will be glad to give you complete details.

Indications of wrong size balls used in makeup charge in an operating mill will be discussed in the next article in this series on ball rationing.

For a reprint of the article on which this ad is based, please write on your company letterhead to: Mining Supply Department, The Colorado Fuel and Iron Corporation, P. O. Box 1920, Denver, Colorado.

OTHER CF&I STEEL PRODUCTS FOR THE MINING INDUSTRY

CF&I Grinding Rods · CF&I Grader Blades · CF&I Industrial Screens
CF&I Mine Rail and Accessories · Wickwire Rope · CF&I Rock Bolts

FORGED STEEL GRINDING BALLS
THE COLORADO FUEL AND IRON CORPORATION
5823

Albuquerque · Amarillo · Atlanta · Billings · Boise · Boston · Buffalo · Butte · Chicago · Denver · Detroit · El Paso · Ft. Worth · Houston
Kansas City · Lincoln (Neb.) · Los Angeles · New Orleans · New York · Oakland · Oklahoma City · Philadelphia · Phoenix · Portland
Pueblo · Salt Lake City · San Francisco · San Leandro · Seattle · Spokane · Wichita

BOOKS

Geological Abstracts, Vol. 5, No. 2, published by *The Geological Society of America*, 419 W. 117 St., New York 27, N. Y., 121 pp., $3.00, 1957.—A collection of abstracts from the publications of several member societies of the American Geological Inst., as well as from other publications in the same field. The abstracts describe experiments in such areas as economic geology, geophysics, and paleontology. • • •

Ion Exchange Resins, 2nd Ed., by Robert Kunin, *John Wiley & Sons Inc.*, 456 pp., $11.00, 1958.—This book is intended to give a broad general picture of the field of ion exchange technology, for those who have recently become interested in the field or those who know only one aspect of it. The second edition has been revised to cover advances made in the eight years since the first edition appeared. The new material includes a chapter devoted to hydrometallurgical applications, and expanded sections on permselective membranes, sugar refining, and specific exchange resins. • • •

Management for Engineers, by Roger C. Heimer, *McGraw-Hill Book Co. Inc.*, 453 pp., $6.75, 1958.—This book acquaints the engineer with such management concerns as costs, standards, materials, taxes, labor, and ethics, and shows the relationship between them and engineering considerations. • • •

Advances in Nuclear Engineering, Vols. I and II, edited by John R. Dunning and Bruce R. Prentice, *American Society of Mechanical Engineers*, 29 W. 39th St., New York 18, N. Y., 1100 pp., $35.00, 1958.—These books deal with the design of nuclear reactors and their cores, educational use of reactors, metallurgy, instrumentation, heat transfer, problems of corrosion and materials, and related topics. The two books are sold as a set, and most of the articles are also available in single-copy format at 30¢ each. • • •

Hot Laboratory Operation and Equipment, edited by Frank Ring, Jr., *American Society of Mechanical Engineers*, 29 W. 39th St., New York 18, N. Y., 376 pp., $17.50, 1958.—This book contains the most complete information currently available on devices and techniques for handling radioactive materials. If this book and the two volumes, *Advances in Nuclear Engineering*, are ordered together, the three can be purchased at the special rate of $45. • • •

Materials Handling Equipment, by D. Oliphant Haynes, *Chilton Publications*, Book Div., 56th & Chestnut Sts., Philadelphia 39, Pa., 636 pp., $17.50, 1957.—This book covers materials handling machines and systems, what they do, and how. Topics covered include basic types of equipment and their capabilities, unit-load handling, techniques for analyzing specific problems, analysis and design of handling systems, and cost analysis. • • •

Order directly from the publisher all books listed below except those marked • • • The books so marked (• • •) can be purchased through AIME, usually at a discount. Address Irene K. Sharp, Book Dept., AIME, 29 W. 39th St., New York 18, N. Y.

Fads and Fallacies, by Martin Gardner, *Dover Publications Inc.*, 920 Broadway, New York 10, N. Y., 365 pp., paperbound, $1.50, 1957.—An appraisal of eccentric and fallacious pseudoscientific systems in physics, chemistry, astronomy, geology, and other branches of knowledge. The book covers the cults, fads, and curious panaceas which have been in recent years, mistaken for scientific theories. • • •

Dictionary of American Biography, Supplement II, edited by Robert L. Schuyler and Edward T. James, *Charles Scribner's Sons*, approx. 756 pp., $15, June 1958.—This new volume in the dictionary series contains 585 biographical articles, including ones on noted men in the mining and metallurgical fields, and is confined to individuals who died during the five-year period 1936-1940 inclusive. • • •

Smoley's Tables, published by *C. K. Smoley & Sons Inc.*, P.O. Box 14, Chautauqua, N. Y.—New 1956 expanded and revised mathematical handbooks include: *Parallel Tables of Logarithms and Squares*, $6.00; *Five Decimal Logarithmic-Trigonometric Tables*, $1.50; *Parallel Tables of Slopes and Rises*, $6.00; *Segmental Functions*, $5.00; *Four Combined Tables* (the above four books in a single volume), $12.00; and *Three Combined Tables* (the first three books listed), $10.00. • • •

Progress Report in Chemical Literature Retrieval, Advances in Documentation and Library Science, Vol. I, edited by G. L. Peakes, Allen Kent, and James W. Perry, *Interscience Publishers Inc.*, 250 Fifth Ave., New York 1, N. Y., 217 pp., $4.75, 1957.—A compilation of papers from two symposiums concerned with the effective utilization of recorded information in the chemical field. The papers deal with research in progress in the indexing field. Literature retrieval systems are discussed in terms of specific applications such as patent searching and geochemical data. • • •

Plant Design and Economics for Chemical Engineers, by Max S. Peters, *McGraw-Hill Book Co. Inc.*, 511 pp., $11.00, 1958.—The first part of this text deals with applied economics, with particular emphasis on economics in the process industries and in design work. The remainder of the book deals with methods and important factors in the design of plants and equipment, including waste disposal, structural design, and equipment fabrication. • • •

(Continued on page 645)

Personnel

(Continued from page 638)

eration of large capacity modern mines. Excellent living conditions; rapid advancement. Apply by letter giving experience, personal status, and salary expected. Location, south. W5916.

General Manager, graduate mining engineer, to take complete charge of an open pit mining company mining phosphate rock. Will have direct supervision of mining, processing, sales, economics, etc., reporting directly to president. Salary, $25,000 to $30,000 a year. Location, east. W5910.

Research Metallurgist, ore beneficiation, to 45, metallurgist or mining engineer, well trained in metallurgy, with aptitude and interest primarily research, to improve current practice in 100-tph copper flotation mill and test various grades and mixtures of massive sulfide ores. Three-year contract. Salary, open. Submit complete record and references with first reply. Location, Mediterranean area. F5884S.

Mining Engineer, young, B.S. in mining engineering, with major or minor in ore dressing, for combination field and laboratory process work with leading phosphate rock mining operation. Location, south. W5677.

Chief Engineer, Assistant Manager, Safety (mining), B.S. in mining engineering, age 35. Experience: mine examination, evaluation, planning, diamond drilling, exploration, stoping, contract mining, block leasing, claim, and assessment layouts. Cost and project analysis, cost accounting. Assistant general manager, surveying above and below ground. Design, drawing up mining machinery, supervising building; 9 years underground experience; safety inspection, first aid, rescue, 2½ years. Prefer west, midwest, or foreign. M-424.

Mining Engineer, single, 26. Four years metal mining experience in open pit and underground. Surveying, engineering, and planning. Desires more varied experience. Presently employed but available on reasonable notice to travel anywhere. M-425.

Three models to help you match your job needs ....

TS-360

Fastest-loading big machine in the business . . . 280 hp moves 20 yd loads at high speed.

In 1957, earth movers the world over bought more Allis-Chalmers motor scrapers than ever before. This growing popularity is the best proof of the productivity and reliability of this outstanding line. There are good reasons for the trend toward Allis-Chalmers construction machinery . . . investigate these advantages before you buy. When you've seen and tried these high-performance motor scrapers, you'll know why more dirt movers every day . . .

Look ahead...*move ahead*...and stay ahead

Books

(*Continued from page 640*)

State Publications

The Relation to Rank of the Apparent Composition of Volatile Matter from Some Alabama Coals, by Reynold Q. Shotts, Technical Report No. 21, Alabama State Mine Experiment Station, *University of Alabama*, School of Mines, University, Ala., 12 pp., first copy free, additional copies 25¢, 1958. Reprinted from *The Journal of The Alabama Academy of Science.*

Annual Report for the Fiscal Year 1954-1955, by Walter B. Jones, *Geological Survey of Alabama*, P. O. Drawer O, University, Ala., postage 5¢, 1956.

Hydrology and Surface Water Resources of East Central Alabama, by Laurence B. Pierce, Special Report 22, *Geological Survey of Alabama*, P. O. Drawer O, University, Ala., 12¢ postage, 1958.

Geology and Ground Water of the Piedmont Area of Alabama, by Jack Baker, Special Report 23, *Geological Survey of Alabama*, P. O. Drawer O, University, Ala., 8¢ postage, 1958.

Index to the Minerals and Rocks of Alabama, by Hugh D. Pallister, Bulletin 65, *Geological Survey of Alabama*, P. O. Drawer O, University, Ala., 55 pp. 5¢ postage, 1955.

Geology and Ground Water in the Monroeville Area, Alabama, by John B. Ivey, Bulletin 66, *Geological Survey of Alabama*, P. O. Drawer O, University, Ala., 109 pp. 8¢ postage, 1957.

Profile Showing Geology Along State Highway 100, Wilcox County, Alabama, by L. D. Toulmin and P. E. LaMoreaux, Map 9, *Geological Survey of Alabama*, P. O. Drawer O, University, Ala., $1.10 postpaid, 1958.

New Genera and Species of Cavernicolous Diplopods from Alabama, by Richard L. Hoffman, Museum Paper 35, *Geological Survey of Alabama*, P. O. Drawer O, University, Ala., 5¢ postage, 1958.

Minerals and Metals of Increasing Interest—Rare and Radioactive Minerals, by Richard T. Moore, Bulletin 163, *Arizona Bureau of Mines*, Director, University of Arizona, Tucson, Ariz., 30¢, 1958.

Exploration and Development of Small Mines, by H. E. Krumlauf, Bulletin 164, *Arizona Bureau of Mines*, Director, University of Arizona, Tucson, Ariz., 25¢, 1958.

One Hundred Arizona Minerals, by Richard T. Moore, Bulletin 165, *Arizona Bureau of Mines*, Director, University of Arizona, Tucson, Ariz., 30¢, 1958.

Blue line prints of a re-drawn copy of the 1924 edition of the **Geologic Map of Arizona** may be purchased from *Dunkin Blueprint & Supply Co.*, Grand Junction, Colo., $4.50 a copy.

Photo copies, consisting of eight black-and-white prints covering the entire 1924 edition of the **Geologic Map** on a scale of about eight miles to the inch may be ordered from the *Southwestern Technical Services*, 234 E. Sixth St., Tucson, Ariz., or from *Tucson Blueprint Co.*, 39 S. 5th Ave., Tucson, Ariz., $10.00 plus mailing charges.

Geologic Map of Superior Mining District, Map 8, *Arizona Bureau of Mines*, Director, University of Arizona, Tucson, Ariz., 50¢, 1958.

Annual Report of the State Inspector of Coal Mines, State of Arkansas, *J. H. Berry, State Mine Inspector*, 505 First National Bank Bldg., Fort Smith, Ark., 32 pp., 1957.

Subsurface Geology of Northwestern Arkansas, by William M. Caplan, Information Circular 19, *Arkansas Geological and Conservation Commission*, 446 State Capitol, Little Rock, Ark., 14 pp., 17 plates, 1 fig., 4 tables, $1.50 plus 10¢ postage, 1957.

Ground-Water Resources of Parts of Lonoke, Prairie, and White Counties, Arkansas, by Harlan B. Counts, Water Resources Circular No. 5, U. S. Geological Survey in cooperation with the *Arkansas Geological and Conservation Commission*, 446 State Capitol, Little Rock, Ark., 65 pp., 7 plates, 8 figs. 8 tables, 50¢ plus 10¢ postage, 1957.

Annual Report; Sand and Gravel for Concrete Aggregate, No. 1, Vol. 52, California Journal of Mines and Geology, *California Div. of Mines*, Ferry Bldg., San Francisco 11, Calif., $1.00, 1956.

Island Mountain Copper Mines, Mariposa County, No. 53, Vol. 53, California Journal of Mines and Geology, *California Div. of Mines*, Ferry Bldg., San Francisco 11, Calif., $2.00, 1957.

Mineral Information Service, a monthly publication, is designed to inform the public on the geology and mineral resources of California and on the usefulness and rocks. It also serves as a news release on mineral discoveries, mining operations, markets, statistics, and new publications. Write to: *California Div. of Mines*, Ferry Bldg., San Francisco 11, Calif., subscription price, January through December, $1.00.

The California Journal of Mines and Geology contains reports on county mineral inventories, mineral utilization surveys, statistical figures, and other articles of interest to the mineral industries. Issued quarterly. Write to: *California Div. of Mines*, Ferry Bldg., San Francisco 11, Calif., price for four issues (January, April, July, October), $3.00.

Bibliography of Mining Theses at U. S. Institutions—Longwall Mining of Oil Shale, by Mark J. Waltch and Donald O. Rausch, Vol. 51, No. 2, *Colorado School of Mines*, Publications Dept., Golden, Colo., $1.00, 1956.

Studies of Colorado Pegmatites, by E. William Heinrich and other, Vol. 52, No. 4, *Colorado School of Mines*, Publications Dept., Golden, Colo., $1.50, 1957.

Subsurface Geologic Methods, revised second edition, compiled by L. W. LeRoy, *Colorado School of Mines*, Publications Dept., Golden, Colo., $7.00, 1957.

Geology and Ground-Water Resources of Central East Georgia, by A. S. Furcron and H. E. LeGrand, Bulletin 64, *Georgia State Div. of Conservation*, Dept. of Mines, Mining & Geology, 19 Hunter St. S. W., Atlanta 3, Ga., 164 pp., 1 map, $1.50, 1956.

The Availability and Use of Water in Georgia, by M. T. Thomson, S. H. Herrick, Eugene Brown, and others, Bulletin 65, *Georgia State Div. of Conservation*, Dept. of Mines, Mining & Geology, 19 Hunter St. S. W., Atlanta 3, Ga., 316 pp., 3 plates, 74 figs, 19 tables, $2.50, 1956.

Zonation of the Middle and Upper Ordovician Strata in Northwestern Georgia, by Arthur T. Allen and James G. Lester, Bulletin 66, *Georgia State Div. of Conservation*, Dept. of Mines, Mining & Geology, 19 Hunter St. S. W., Atlanta 3, Ga., 110 pp., $1.50, 1957.

U. S. Bureau of Mines

Request free publications from:

Publications Distribution Section
U. S. Bureau of Mines
4800 Forbes Street
Pittsburgh 13, Pa.

RI 5320 Copper Mines and Prospects Adjacent to Landlocked Bay, Prince William Sound, Alaska.

RI 5322 Electrowinning Chromium Metal.

RI 5323 Percolation Leaching of Manganese Ores with Sulfur Dioxide.

RI 5327 Recovery of Tin and Tungsten from Tin-Smelter Slags.

RI 5328 A Field Test for Selenium.

IC 7771 Bibliography of Zirconium.

RI 5329 A Convenient Table for Determining Metastable Transitions in Mass Spectra.

RI 5330 Pilot-Plant Flotation of Manganese Ore from the Maggie Canyon Deposit, Artillery Mountains Region, Mohave County, Ariz.

RI 5332 Analyses of Tipple and Delivered Samples of Coal (Collected During the Fiscal Year 1956).

IC 7780 Mining and Milling Methods and Costs, Tri-State Zinc Inc., Jo Daviess County, Ill.

IC 7781 Mining Methods ond Costs at the Hayden Creek Mine of St. Joseph Lead Co., St. Francois County, Mo.

IC 7783 Methods and Costs of Deepening the Crescent Shaft, Bunker Hill & Sullivan Mining and Concentrating Company, Kellogg, Shoshone County, Idaho.

IC 7785 Studies on the Development and Control of Coal-Dust Explosions in Mines.

IC 7786 Mining Methods and Practices at the Mineral Hill Copper Mine, Banner Mining Co., Pima County, Ariz.

RI 5341 Caustic Leaching of Manganese Flotation Concentrate From Artillery Peak, Ariz.

RI 5342 Lead-Precipitation-Flotation Tests of a California Copper-Gold Ore.

RI 5343 The Miners Queen Copper Deposit, Skamania County, Wash.

RI 5344 Investigation of Fluorspar Deposit, Kaiser Mine, Mineral County, Nev.

IC 7792 Bureau of Mines Approval System for Respiratory Devices (Revision of IC 7800).

RI 5346 Electric Smelting of Cuban Serpentine and Laterite Nickel Ores.

RI 5347 Manganese Dioxide Prepared from Manganous Hydroxide.

RI 5348 Roof-Span Studies in Limestone.

RI 5349 Low-Temperature Chlorination of Columbium-Bearing Titanium Minerals.

RI 5351 Utilization of South Arcot, India, Lignite.

RI 5353 Experiments on Water Infusion in the Experimental Coal Mine.

IC 7793 Mining Methods and Costs at the Sunbright Limestone Mine, Foote Mineral Co., Sunbright, Va.

IC 7798 Injury Experience in the Metal and Nonmetal Industries, 1954. Detailed Analysis of Safety Factors and Related Employment Data; and Unpublished Statistics for 1943-1953.

RI 5360 Effectiveness of Bleeder Entries in Ventilating Pillared Areas of Bituminous-Coal Mines.

RI 5362 Iowa Coals as a Source of Sulfur.

RI 5363 Survey of Fire-Fighting Facilities at Coal Mines.

RI 5364 Vapor Pressures of Liquid Iron and Liquid Nickel.

IC 7800 Mining, Processing, and Costs—Idaho Almaden Mercury Mine, Washington County, Idaho.

IC 7803 Mining Methods and Costs—La Sal Mining & Development Co., La Sal Uranium Mine, San Juan County, Utah.

U. S. Bureau of Mines

Copies sold through:

Superintendent of Documents
U. S. Government Printing Office
Washington 25, D. C.

Bulletin 550 Petrography of American Coals, $1.75.

IC 7784 Molybdenum. A Materials Survey, chapter on Geology and Resources, 75¢.

Bulletin 561 Zirconium: Its Production and Properties, $1.00.

Bulletin 563 Combustion of Solid Fuels in Thin Beds, 65¢.

Bulletin 567 Analyses of Ash From United States Coals, 30¢.

U. S. Geological Survey

Copies sold through:

U. S. Geological Survey
Dept. of the Interior
Washington 25, D. C.

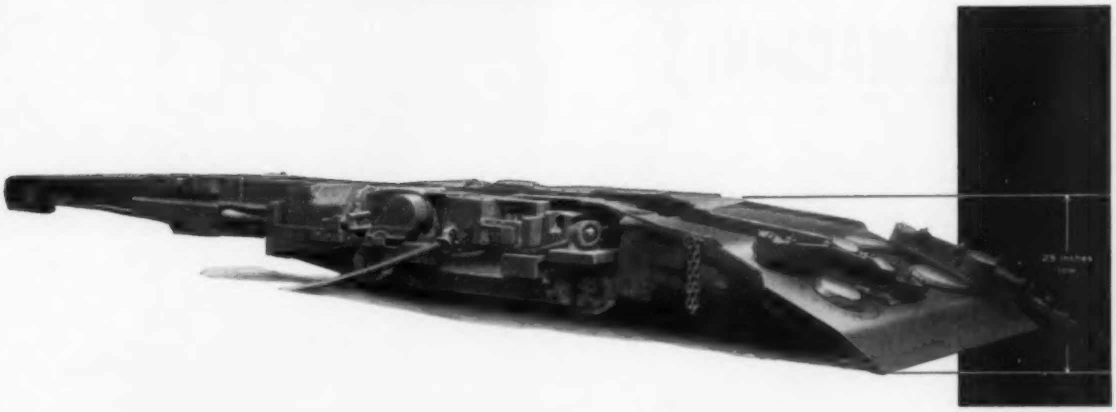
Miscellaneous Geologic Investigations Map I-270-B Arabian Peninsula, scale of 1:2,000,000, 48x55 in., printed in English, $1.50.

Copies sold through:

Superintendent of Documents
U. S. Government Printing Office
Washington 25, D. C.

Suggestions to Authors of the Reports of the United States Geological Survey, fifth edition, approx. 252 pp., $1.75.

for high capacities in low seams... 400 tons per shift



JEFFREY 81-C Loaders

Gathering head on Type 81 Jeffrey crawler loaders is fully gear driven; no chain drives between head motors and gathering arms.

Just 25 inches high, this newest Jeffrey crawler loader is ideally suited for low seam work. Offers the same time-tested features that made Jeffrey's 81-A and 81-B loaders so popular . . . fast, easily maneuvered, highly productive.

The Jeffrey 81-C loader is powered by four 15 HP electric motors and a 4 HP hydraulic motor . . . power for the toughest jobs. It has a rated capacity from 6 to 10 tons per minute . . . averaging 400 tons per shift in 33" seams, keeping loading costs to a minimum. Moves fast from place to place, hits loading stride quickly and stays on the job until the work is done.

Like all Jeffrey mining machinery, Jeffrey loaders are available for either AC or DC power. With Jeffrey equipment you can make your mine all-AC.

Flexibility built into the Jeffrey loader lets it work most efficiently with other face equipment and the same mining cycle. Conveyor swings 45° either side of center and elevates properly to load shuttle cars on the straight or in break-throughs. Can be turned in its own length.

THE JEFFREY MANUFACTURING COMPANY
885 North Fourth Street, Columbus 16, Ohio

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

"BIGGEST" OPEN PIT OPERATION IS HANDLED BY CAT MACHINES

Cat DW21 (Series C) Tractor with Athey PR21 Wagon removing overburden in an open pit copper mine in Northern Rhodesia. Their speed and power make them fast, dependable producers.

With a spread that includes 26 of all types of Cat machines—working the largest open pit copper mining operation in Africa—a mining company in Northern Rhodesia is excavating 600,000 tons of earth and ore per month.

This owner has purchased Caterpillar machines because of their ability to keep going 23 hours a day (one hour required for servicing)—with a minimum of down time. A matched fleet of Cat DW20 (Series E) and DW21 (Series C) Tractors with Athey Trailers spearheads the job, and has the speed, guts and capacity that add up to a low cost-per-cu.-yd. figure.

Cat wheel-type Tractors have always had the rimpulls and fast-cycle potential to enable owners anywhere to meet production dates at an operating profit. Now new DW21 (Series D) and DW20 (Series F) Tractors are available. They feature the new Cat Super-Turbo Engine—that produces 320 HP (maximum output) and 28% torque rise!

Athey Trailers feature low center of gravity and plenty of ground clearance for excellent roadability. And both the Caterpillar and Athey units have the built-in dependability to get the job done without costly lay-ups for major overhaul.

Remember, your operators and mechanics prefer Cat machines. End result is: greater efficiency—high production from your crews.

Get in touch with your Caterpillar Dealer TODAY for a demonstration. He will explain why resale and trade-in values stay high. Standardize with Cat machines; stand to make more profit on the job.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

THE ONLY COMPLETE TRACTOR-TRAILER LINE... BY THE LEADERS

Manufacturers News

News
Equipment
Catalogs

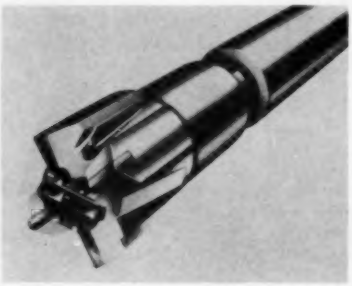
• FILL OUT THE CARD FOR MORE INFORMATION •

Jaw Crusher

Biggest of an expanding line, the new 30x42-in. jaw crusher by *Eagle Crusher Co.* is rated at 125 to 400 tph. Jaws are adjustable from ½ to 8 in. while unit operates. Overall weight is 55,000 lb. **Circle No. 1.**

Rototool

Percussive action of the new *Schramm Inc.* Rotatool, designed for use with Schramm Rotadrills, is contained within the tool and power is conserved for faster drilling



through hard formations. Special bit has six carbide tips, and can be reground. **Circle No. 2.**

Filter Media Support

National Filter Media Corp. is distributing a saran and polyethylene fiber fabric, Trilok, designed for use as a filter media support and drainage member for wet process filters. Smooth surface allows long media

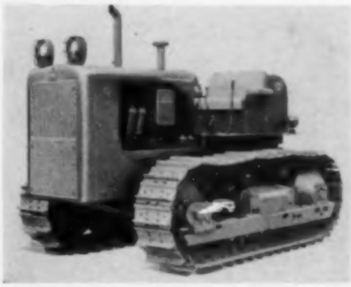
life. No undercovers are needed even with lightest media and honeycomb structure gives good hydraulic flow. **Circle No. 3.**

Rubber Pipe Lining

A switch from heavy cast iron pipe to rubber-lined steel for handling highly abrasive slurries not only doubled pipe life, in one case, but also saved about 20 days a year in patching and turning the pipe, reports *American Hard Rubber Co.* The company has developed a ¼-in. thick rubber compound lining designed especially for handling abrasive materials. **Circle No. 4.**

New Diesel Crawler

A six-speed full reverse transmission is featured in the new 134-hp diesel International TD-20 tractor by



Construction Eqpt. Div. of *International Harvester Co.* When directional "shuttle bar" shift lever is moved the tractor travels forward or reverse in any pre-selected speed range. Operating weight is 29,300 lb. **Circle No. 5.**

Quick-Change Load Socket

With a new double wedge socket by *Page Engineering Co.*, one man equipped with a small sledge can

easily release a load cable in a few minutes. Large, removable top wedge allows fast cable wrap; small, bottom wedge slides on a pin and slot arrangement. A short tap on either wedge does the job. Wide range of sizes available. **Circle No. 6.**

Belt Feeder

The new F-8 belt feeder by *Barber-Greene* offers a capacity range of 5 to 550 tph and features very low head room. Two drives offered:

gearmotor and roller chain or variable speed reducer and roller chain. Idlers are closely spaced to prevent spillage. **Circle No. 7.**

Improved Hard Hat

Built-in safety clearance in a new *Mine Safety Appliances Co.* Skullgard prevents the wearer from adjusting his cap in an unsafe way. Without this clearance a heavy blow may cause hat-to-head contact. New suspension is comfortable, easily inserted and removed, quickly adjusted. **Circle No. 8.**

Rotary Drill Rig

George E. Failing Co. has a versatile portable rig designed to use rock, drag, and down-the-hole bits. Unit is mounted on a GF-660 Crane Carrier truck with a GMC 4-71 diesel engine which is used to power the rotary table. Air compressor is

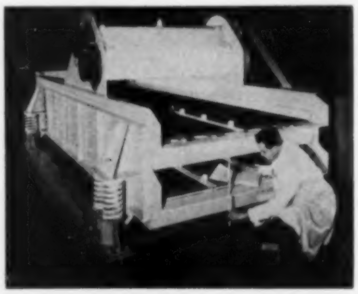
a Le Roi 100-S2 powered by a GMC 6031-C diesel. Three hydraulic leveling jacks are standard equipment. **Circle No. 9.**

Limestone Blasting

An economical, small-diameter Accomite blasting agent has been announced by the Explosives & Mining Chemical Dept. of *American Cyanamid Co.* With minimum diameter of 1½ in. and 16-in. length, cartridge count is 45 per 50 lb. Results in limestone mining field tests were excellent, reports Cyanamid. Agent requires primer, is insensitive to a No. 8 electric cap. **Circle No. 10.**

Vibrating Screen

Link-Belt Co. has a new heavy duty Straightline horizontal vibrating screen, CL-Model 58, designed for dewatering, washing, and sizing. Single or double deck units are available in 15 sizes ranging from



4x8 ft to 6x16 ft. Vibrator gears are mounted on tapered shafts for quick replacement of cartridge-mounted bearing. **Circle No. 11.**

Water System Controls

Valves can be opened and shut, pumps operated, reservoir levels indicated, and a complete water system monitored and operated with new Audio Tone units by *Femco Inc.* Wiring required: a single pair of leased telephone lines. **Circle No. 12.**

Locomotive Service Stations

General Electric has set up 11 major repair centers to speed the overhauling of industrial locomotives. A complete overhaul can be done in four to six weeks—doubling the useful life of the units. Major centers are in New York, Pittsburgh, Cleveland, Dallas, San Francisco, Atlanta, Salt Lake City, Boston, Chicago, Minneapolis, and Portland, Ore. **Circle No. 13.**

News & Notes

Dow Chemical Co. has just opened a terminal near Grants, N. M., for stocking the chemicals heavily used by uranium mills. . . . *W. S. Tyler Co.* has been publishing its little magazine "Through the Meshes" for 50 years. . . .*Allis-Chalmers* is experimenting with a crawler tractor powered by a high speed gas turbine. . . . *Western Machinery Co.* will sell and service the Michigan line of tractor shovels, dozers, scrapers, and excavator cranes made by *Clark Eqpt. Co.* . . . *Brunner & Lay's* new Sacramento plant has complete drill steel facilities . . . *Atlas Copco Eastern Inc.* has moved its general headquarters from Paterson, N. J., to larger quarters at 610 Industrial Ave., Paramus, N. J. . . . *R. G. LeTourneau Inc.* will enter the earthmoving field again shortly. May 1 marked the end of a sale agreement to market no earthmovers for a five-year period. . . . *Commercial Testing & Engineering Co.* celebrates its Golden Anniversary this year.

(21) SUBMERSIBLE PUMPS: Three new catalogs from *Stanco Mfgs. & Sales Inc.* cover the complete line of Flygt submersible electric pumps. Units range in size from 1½ in., 85 gpm to 8 in., 3000 gpm. Head capacities range to 210 ft.

(22) MAGNETIC PULLEYS: *Stearns Magnetic Products* has a new booklet covering the Stearns Series 410 and 710 Indox V permanent magnet pulleys for tramp iron separation in belt conveyor systems. Units feature an exclusive ceramic magnet material. Details in bulletin P-1021.

(23) CRUSHING ROLLS: *Traylor Engineering & Mfg. Co.* supplies data on crushing rolls in a new bulletin that gives much useful information. Bulletin 6637 has charts, exploded drawings, and details on the three types of Traylor rolls.

(24) TESTING SIEVES: *W. S. Tyler Co.* has made available a catalog on "The Profitable Use of Testing Sieves." Catalog 53 details the matched Ro-Tap sieve shaker and Tyler standard screen scale testing sieves.

(25) TWIN-BEARING SCREENS: An extra-heavy shaft, large bearings, and easy takedown are features of the Seco twin-bearing screens by *Screen Eqpt. Co. Inc.* Details in booklet TB-21.

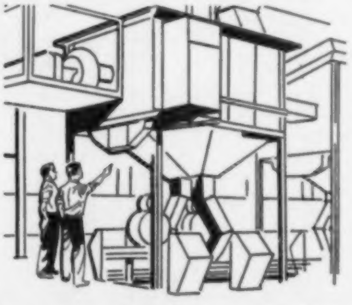
(26) SHAFT MOUNTED DRIVES: New 32-page bulletin 7100 from *Falk Corp.* describes the complete line of Falk all-steel, helical gear, shaft mounted drives for applications in the ½ to 50 hp range.

(27) MINING EQUIPMENT: *International Harvester Co.* has released a 16-page catalog on "Production Equipment for Modern Mining." Booklet CR-607-H shows the application of International crawler tractors, off-highway haulers, power units, scrapers, and drilling equipment in all phases of the industry.

Free Literature

(28) THERMOMETERS: New 56-page catalog C60-2 from the Industrial Div., *Minneapolis-Honeywell Regulator Co.* describes the Brown line of rectangular case filled system thermometers. The instruments are used as indicators, recorders, transmitters, and electric or pneumatic controls.

(29) DUST CONTROL: *W. W. Sly Mfg. Co.* has a 36-page book on dust control systems. Included is data on



the new Roll-Clean Dynaclone, which has a roller mechanism for cleaning filter bags while unit is operating.

(30) DEMOLITION TOOL ACCESSORIES: A comprehensive catalog covering a line of demolition and digging tools and accessories is available from *Ingersoll-Rand.* The 24-page bulletin, Form 4190, includes a useful page on reforging, sharpening, and hardening these tools. A special section details safety tools of forged beryllium copper for spark-free work. In all, 16 varieties of tools and 64 accessories are described.

(31) LAB APPARATUS: More than 250 items of laboratory equipment are covered in 43-page catalog 57G from *Eberbach Corp.*

(32) DUST COLLECTOR VALVES: *Ducon Co. Inc.* has two new data sheets covering free-discharge valves for dry dust collectors. V-957 details a two-door discharge gate unit, and V-6157 covers a trickle valve which uses gravity for automatic operation.

(33) MAGNET DRUM: Type DP, a new permanent magnet drum by *F. W. Shrader Co.* requires no belts or idlers—material is fed directly onto the stainless steel drum. Catalog sheets M-12 and M-14 give details.

(34) WIRE ROPE SLINGS: *Lowery Bros. Inc.* has developed an order form which takes the guesswork out of ordering wire rope slings. Dept. MIN will supply samples.

(35) WHEEL STOPS: A portable wheel stop assembly for full-size rail cars is offered by *Calumet Steel Castings Corp.* Twin, interlocking clamps secure the device on the rail.

(36) PUMP SELECTION: *Nagle Pumps Inc.* offers Selector Bulletin 158, which briefly describes a line of pumps for abusive applications involving corrosion, abrasion, high temperature.

(37) INDUSTRIAL MINERAL MILLS: A 30-page catalog on the *Bradley Pulverizer Co.* line of semi-fine and fine pulverizing screen and pneumatic roller mills is available. Mills are best suited for grinding phosphate rock, limestone, gypsum, coal, talc, perlite, and similar materials.

(38) SAMPLER: *Galigher Co.* offers bulletin S-056 detailing the Geary-Jennings sampler, designed for automatic representative sampling of liquids, slurries, and solids. The 18-page brochure supplies specifications and detailed diagrams.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

6

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after September 15, 1958—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

Name__________ Title__________

Company__________

Street__________

City and Zone__________ State__________

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64						

Students should write direct to manufacturer.

(39) VIBRATORY SCREENS: *Syntron Co.* has announced a new 14-page catalog listing complete data on Syntron pulsating-magnet screens, concentric-action screens, unbalanced-pulley screens, Grizzly Bar screens, and screening feeders.

(40) SECTIONAL V-BELTS: Dixlink is a new adjustable V-belt which can eliminate the need for stocking many lengths of belts of the same type. A single coil can be used for a variety of units which do not require endless belts. New belt, by *R. & J. Dick Co.*, is made for V-belt drives of from ½ to 1000 hp.

(41) WOVEN STEEL SCREENS: *Manganese Steel Forge Co.*—maker of the Rol-Man improved double-

lock mesh woven manganese steel screens—offers a new catalog on their use.

(42) MINE & MILL MACHINERY: *Nordberg Mfg. Co.* displays its complete product line in a new 12-page brochure. Latest designs of Nordberg diesel, Duafuel, and spark-ignition engines are included with ratings. Also covered are Symons crushers and screens, Nordberg grinding mills, rotary kilns, mine hoists, in bulletin 271.

(43) CONTROL VALVES: The Valve Div. of *Minneapolis-Honeywell Regulator Co.* has a 4-page bulletin on Honeywell series 800, 3-way control valves for mixing and diverting. Ask for Specification S810-16.

(44) VIBRATORY FEEDERS: *Syntron Co.* has a new 32-page booklet containing complete data and specifications for its 13 standard vibratory feeders, three hydraulic and/or pneumatic feeders, and spiral elevator feeders. Included are schematic layouts and feeder applications.

(45) WIRE ROPE STORAGE: A new bulletin on "Storage and Lubrication of Wire Rope" is offered by *Leschen Wire Rope Div.*, H. K. Porter Co. Inc. Putting into storage and then back into service is discussed along with need for proper lubrication. Details in bulletin 103.

(46) MACHINERY HEADLIGHT: An explosion-proof, water-proof sealed beam headlight for mine service is available from *Goodman Mfg. Co.* Unit weighs less than 10 lb and can usually replace old style lights without drilling new bolt holes. Choice of floodlight or spotlight style.

(47) ROAD MACHINERY: *Huber-Warco Co.* offers a 32-page brochure covering their line of road machinery products. Outlined are features of motor graders, tandem and 3-wheel rollers, and a maintainer.

(48) WAGON DRILLS: *Ingersoll-Rand's* new brochure 4191 describes the company's three models of wagon drills—the FM-4 wagon drill, the FM-4 rotary, and the light-weight JHM Wagonjack mounting. The first is a percussion drill for sustained hard use as in quarry work, the second for fast drilling with fishtail bits in soft formations, and the last for locations where a light-weight rig is needed. All are one-man operated.

(49) BELT CONVEYORS: *Jeffrey Mfg. Co.* has published a handbook designed to cover the field of materials handling by conveyor. Catalog 909 offers concise advice on a complete line of conveyor equipment and includes much practical engineering data.

(50) CARBIDE INSERTS: Folder E-568 from *Atlas Copco* discusses the carbide inserts now incorporated in Sandvik Coromant integral drill steels. Four-page folder shows how the inserts have been enlarged and compares effective footage achieved.

(51) ROCK DRILL: *Atlas* Copco leaflet E-1097 describes the company's new Terrier rock drill, which is designed primarily for bolt-hole or other short hole drilling.

(52) PUSHER LEGS: BMK automatic pusher legs for rock drills by *Atlas Copco* are detailed in publication E-1106. Cutaway drawings are included with data.

(53) HOSE FITTINGS: Catalog 4440 from *Parker-Hannifin Corp.* details reusable Hoze-lok fittings for use with rubber covered wire braided hydraulic hose in sizes 3/16 to 1⅛-in. ID.

(54) TRANSIT: *Wild Heerbrugg Instruments Inc.* offers a descriptive brochure on the Wild T-1 optical repeating transit.

(55) STOP BELT CARRYOVER: Material adhering to a conveyor belt after it has passed the header roll can be conveniently removed with the Rotamaster brush by *Osborn Mfg. Co.* Brush causes less wear than scrapers, says Osborn, and is self-cleaning.

(56) NORMALIZING KIT: *Caterpillar Tractor Co.* now has a kit for the No. 12 motor grader to eliminate reduced engine horsepower caused by high-altitude operation.

(57) TRACTOR SCRAPERS: A 24-page catalog on Michigan 110, 210, and 310 tractor scrapers is available from Construction Machinery Div., *Clark Eqpt. Co.* Scrapers have heaped capacity of 10½, 18, and 27 cu yd.

(58) METAL PROTECTION: A new 36-page protective coatings manual has been released by *Rust-Oleum Corp.* Included are color chips of 102 different coating items. Catalog, 257, has sections on surface preparation, primer use, finish coatings, and custom surfaces.

(59) ACID REGENERATION: Information on a system that automatically increases acid regenerant concentration to the cation units of *Graver Water Conditioning Co.* demineralizers at prescribed rates is available. System provides optimum cation exchange performance, reproducible results, and minimum supervision.

(60) PREFABRICATED TIMBER: A booklet from the Oregon firm, *Rosboro Lumber Co.* features types and uses of prefabricated lumber and timbers. Economy and time-saving are stressed.

FIRST CLASS
PERMIT No. 6433
Sec. 34.9 P.L.&R.
New York, N. Y.

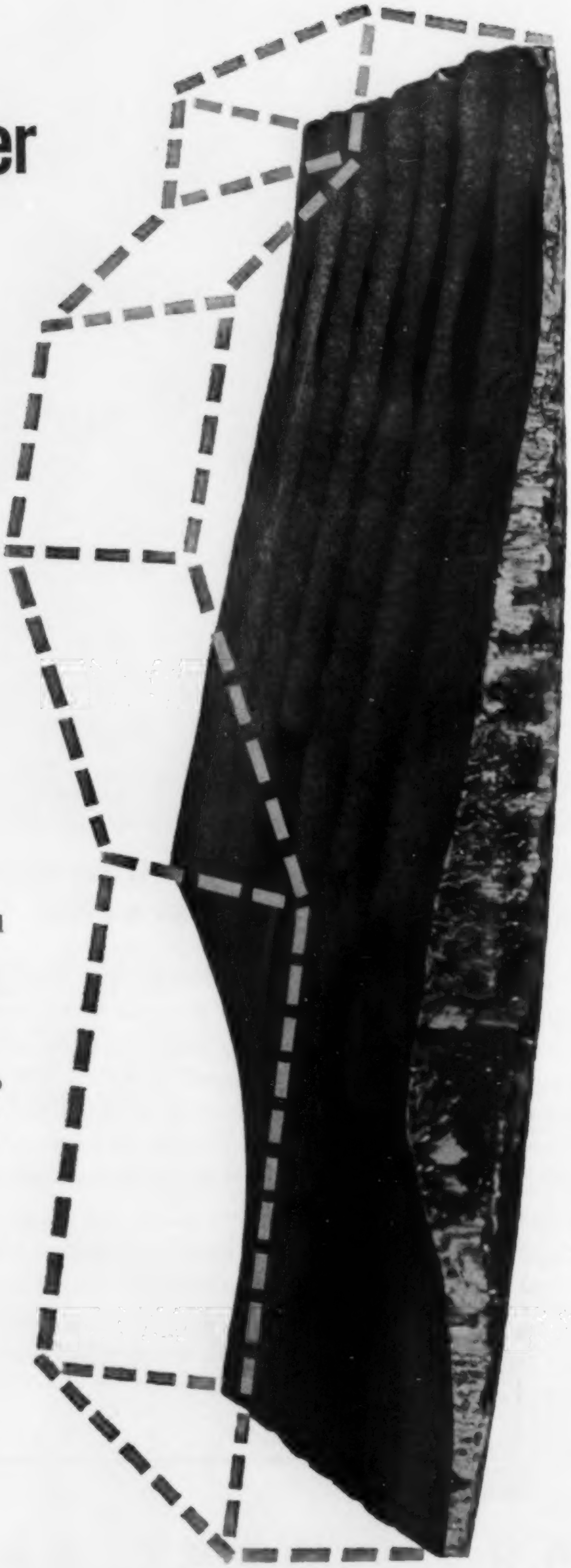
BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

3c.—POSTAGE WILL BE PAID BY—

MINING ENGINEERING

29 WEST 39th STREET

NEW YORK 18, N. Y.



New Mineral Price Support Plan Advanced

Interior Secretary Fred A. Seaton has introduced an Administration plan that proposes to subsidize domestic producers of copper, lead, zinc, acid-grade fluorspar, and tungsten. As planned, producers would be paid the differences between the domestic market price and a predetermined stabilization price, with limitations on the acceptable yearly tonnages. The plan would extend over a five-year period and cost an estimated $161 million the first year—and less thereafter, it is hoped, as the "economy resumes its long-term health and vigor." Called-for stabilization prices and annual limitations are as follows:

> Copper, 27½¢ a pound, 1 million tons; lead 14¾¢ a pound, 350,000 tons; zinc, 12¾¢ a pound, 500,000 tons; fluorspar, $48 a short ton, 180,000 tons; tungsten, $36 a short ton unit, 375,-000 short ton units.

Mr. Seaton declared he would oppose tariff help for the lead-zinc industry if the new plan was approved by Congress, saying the plan made recommendations of the Tariff Commission "largely academic." He also voiced the belief that price floors would be unnecessary since producers would not cut prices unduly. Commenting that the plan was designed to set adequate prices for efficient operations, he said it would be small help for high-cost mines. The plan was met with immediate disfavor in many segments of the industry, although some appeared to think that, with inevitable revisions, the scheme would take on a different light. See *Trends*, page 661, for more details and industry comments.

Kennecott Cuts Back Again

"To bring production more nearly into line with current demand and to prevent further inventory increases," Kennecott Copper Corp. has curtailed its copper output for the third time this year. Utah, Nevada, Arizona, and New Mexico operations have been cut to the point that production is now 67 pct of the 1957 rate.

New Output Curbs by New Jersey Zinc

New Jersey Zinc Co.'s Hanover, N. M., mine has been closed and operations of the Canon City, Colo., roasting plant have been discontinued. The company also announced cutbacks at smelting plants at Palmerton, Pa., and Depue, Ill.

Inco Slows Production Further

Another 10 pct cut in nickel output has been made by the International Nickel Co. of Canada Ltd. Since the company produces copper in about the same quantity as nickel, output of the red metal will be similarly affected. Present cutbacks notwithstanding—a previous 10 pct cutback was announced in March—Inco plans to continue long-term expansions.

Chop Price of Titanium

Titanium Metals Corp. of America has announced prices of its mill products have been reduced an average of about 10 pct, due to new mill methods and success of a new Toronto, Ohio, plant.

Asarco Signs New Coeur d'Alene Lease

American Smelting & Refining Co. has taken a 99-year lease on properties of the Jack Waite Mining Co. and has agreed to spend a minimum of $100,000 on their exploration and development. The lead, zinc, and silver holdings are located in Idaho and in Sanders County, Mont. Lease supercedes previous 40-year agreement signed in 1934.

On the Coal Scene . . .

Establishment of an Office of Coal Research within the Interior Department has been proposed to encourage output and conservation of national coal reserves and help promote a healthier industry . . . . USBM reports the 14 coal fatalities in March were the fewest for a month in almost 50 years. Falls of roof, face, and ribs continued as the leading cause, being responsible for eight of the deaths . . . . Pittsburgh Consolidation Coal Co. is now known as Consolidation Coal Co. . . . One of the biggest automated coal preparation plants is being built by Link-Belt Co. for Clinchfield Coal Co. The Clinchfield, Va., plant will be known as Moss No. 3 and will wash, dry, and screen 1500 tph of run-of-mine coal.

New Hand On Mesabi Helm

A group of dissatisfied Mesabi Iron Co. stockholders rose up on April 19 to elect a new board of directors, selecting as new president Arnold Hoffman, former vice-president and leader of the revolt. Key points in the battle: accused management lethargy and Mesabi's dispute with Reserve Mining Co. over accounting procedures involved in one-third profits due Mesabi for taconite operations on its Minnesota holdings. Latter dispute is being arbitrated.

Kennecott Buys Garfield Smelter

The world's largest copper smelter, the Garfield near Salt Lake City, has been sold to Kennecott Copper Corp. by American Smelting & Refining Co. for $20 million. Title transfer of the 625,000 tons-per-year concentrate producer is expected to take place January 2, 1959. Another integration step for Kennecott, the sale also provides Asarco with further capital for diversification in the production of industrial raw materials. The Kennecott Bingham mine will supply all ore needed; custom ores from other western mines will be treated at other Asarco smelters. No change will be made in the jointly-owned Garfield Chemical & Mfg. Corp.

New Technical Center Projected

Foote Mineral Co. has plans for new laboratories and may start construction on a 54-acre tract near Exton, Pa., next year. L. G. Bliss, president of the lithium producer, commented, "Our policy of investing a substantial part of our earnings in research has been our trademark in the past, and we see no reason to interrupt a successful policy even in the face of an economic lull."

Shaft Mucker Patent Upheld

Canada's Exchequer Court has upheld the Canadian patent on the Riddell shaft mucker. An injunction and damages for patent infringement were awarded against Patrick Harrison & Co. Ltd. of Noranda, Que. Plaintiff J. Murray Riddell also holds U. S. patents on the unit.

All around . . . underground . . . GARDNER-DENVER keeps production stepping

In blast hole drilling . . .

DEEP HOLE DRILLS—developed especially for the job. Some mine properties report breakage costs reduced as much as 75% using Gardner-Denver deep hole drills.

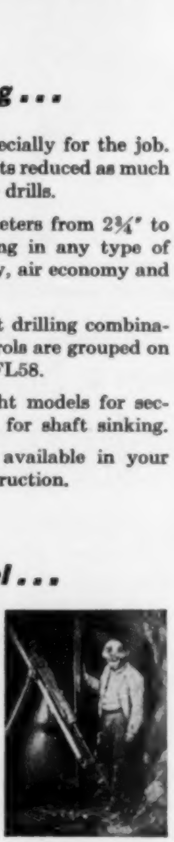
DRIFTERS—a choice of hammer diameters from 2¾" to 4½", with feeds and controls for drilling in any type of rock. Outstanding in hole-cleaning ability, air economy and drilling speed.

AIR FEED LEG DRILLS—lightweight drilling combination designed for ease of operation. Controls are grouped on drill backhead. Two models: FL48 and FL58.

SINKERS—a complete line. Lightweight models for secondary breakage and heavy-duty drills for shaft sinking.

STOPERS—Three rugged models. All available in your choice of feeds, controls and chuck construction.

In quality drill steel . . .



SECTIONAL DRILL RODS—highest quality . . . shot-peened and carburized to stand the down-the-hole gaff longer.

RING SEAL SHANKS—replace old-type water swivels without adding additional length to drill.

COUPLINGS—extra long, extra hard threads for longer drilling life.

In mucking operations . . .

MINE CAR LOADERS—four rugged, high-capacity loaders with fast action and plenty of mucking power. Models to meet various headrooms and car sizes. Safe, easy to use . . . have low center of gravity.

"AIRSLUSHERS"—three Gardner-Denver load-lugging slusher hoists available. Powered by high-torque, five-cylinder radial air motors. Motor and drive completely enclosed to keep out dirt and water.

In jumbo drilling setups . . .

HYDRAULIC DRILL JUMBOS—rail-mounted jumbo units with one, two or three booms, in your choice of drills and feeds.

JMT "MOBILJUMBO"®—a self-propelled, push-button drilling unit. Available with two or three booms . . . with drills and feeds to suit your ground.

JUMBO COMPONENTS—build your own jumbo with Gardner-Denver drills, feeds, hydraulic booms, remote controls and drill positioners. A combination for every drilling need.

With air power . . .

ROTARY PORTABLE COMPRESSORS—five sizes, wheel- or skid-mounted.

STATIONARY WATER-COOLED COMPRESSORS—single- and two-stage units in capacities to 1854 cfm.

Plus . . .

Bit Grinders • Centrifugal Pumps • Grout Pumps • Air Hoists • Columns • Drill Steel Shapers and Sharpeners • Sump Pumps • Maintenance Tools • Oil Forges • Air Line Oilers • Air Motors

GARDNER-DENVER Since 1859

KELLER TOOLS

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois
Export Division, 233 Broadway, New York 7, New York
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

marcy mills...

"No Compromise with Quality"

YOUR ASSURANCE OF

▶ **low net-cost-per-ton grinding**

AND

▶ **long operating life**

Since 1915...

seven 8'x 6' Marcys, purchased in 1915 by a U. S. copper company, are now being used in a Philippine Island mill. After 43 years these mills are still operating with their original gears.

For 15 Years...

these 10'x 10' Marcys have been operating in a large copper mill. There have been no bearing problems and the original gears are just now being reversed.

Since 1915...

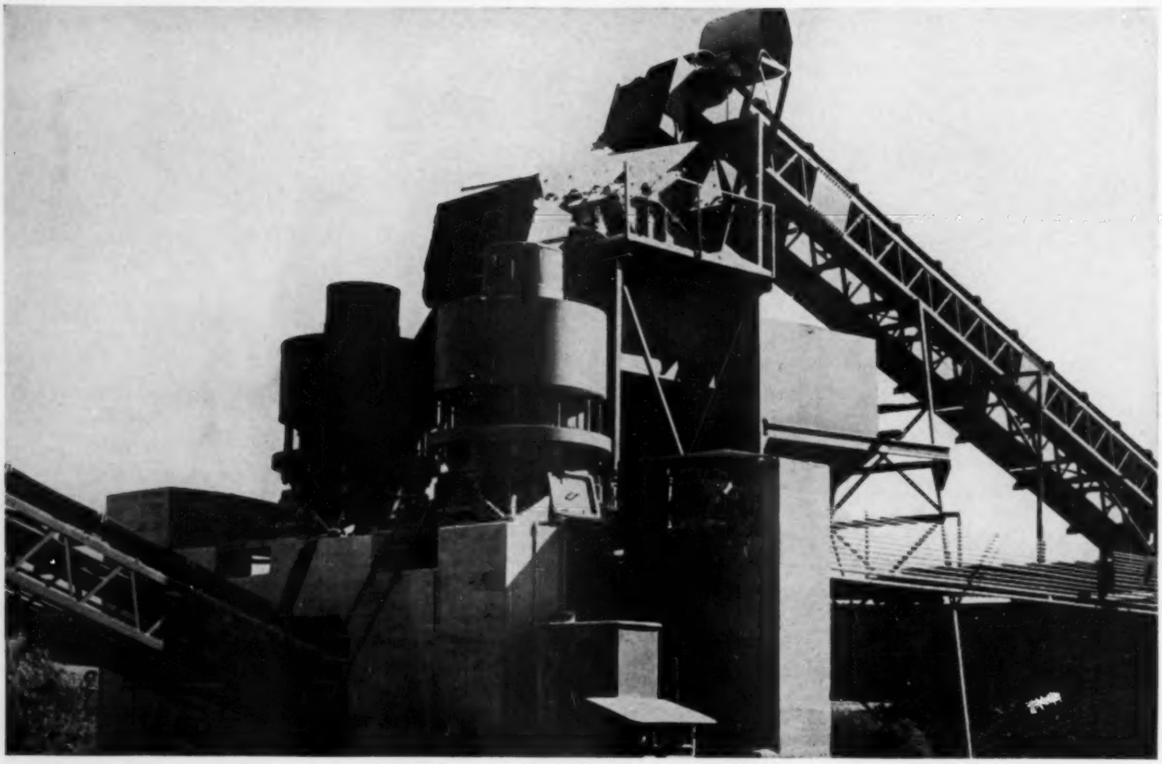
this 8'x 6' Marcy is still working 24 hours per day in a large cement plant after 43 years of dependable mechanical operation.

THE MINE AND SMELTER SUPPLY CO.

DENVER 16 · 3800 RACE
NEW YORK 17 · 122 E. 42ND ST.
SALT LAKE CITY 1 · 121 W. 2ND S.
EL PASO · P. O. BOX 1162

SALES AGENTS AND LICENSED MANUFACTURERS THROUGHOUT THE WORLD

MARCY®



The New Subsidy Plan

The problem of maintaining a healthy domestic minerals industry in the face of heavy imports from foreign mines with cheaper labor and usually better grade ore has troubled the U. S. for years. The recent economic difficulties have compounded the enigma with a succession of mine closures following an erratic downtrend in prices. On the domestic producers' side spokesman argue that U. S. mines must be kept producing. Since, in the event of war, it will not be possible to obtain all necessary mineral materials from foreign sources, the upkeep of domestic mines is a must for survival. Important as foreign friendships may be, they note, our own industry and our own workers should be the first consideration.

Contrary opinion holds that producing mines will be little if any help in the type of warfare augured for the future. The initial attack would be countered with devastating reprisals and a major war would last only the time required for each side to throw all possible weapons at the enemy. Immediate preparedness, not productive potential, would tell the tale. Therefore, why should the nation burden taxpayers with supports for an industry employing relatively few people, they ask, and why should we annoy allied nations by thwarting free trade with quotas and tariffs on key mineral goods.

The answer to satisfy both sides completely has not been found, nor is it likely that it will be. The Administration is torn by a desire to keep friendly foreign relations and promote trade on one hand, and, on the other, to maintain strength in an industry which has been a major factor in the country's growth and prosperity.

In the face of some domestic demands for tariffs and quotas on foreign metals—and such measures have recently been recommended by the Tariff Commission—the Government has attempted to take a stand that will both help the desperate home operators and placate the violent protests of certain, usually friendly, foreign countries. The result is the plan, introduced by Secretary of the Interior Fred A. Seaton (see Reporter, page 655), which schedules subsidy payment to domestic producers when market prices go below certain Government-set figures.

With the new plan the Administration intends, in the words of Secretary Seaton, to "create an economic bridge across the present and temporary valleys of low consumptive requirements, which we confidently expect to be corrected by [an] upswing in the general economy." The program is intended to last five years and would cost an estimated $161,-090,000 the first year. Thereafter, yearly costs are expected to decrease as the "economy resumes its long-term health and vigor." In addition, certain safeguards will be incorporated into the final legislation "to insure the equitable distribution of stabilization payments within each industry."

Industry reaction to the Administration proposals was, first of all, surprise. The recent Tariff Commission recommendations for higher lead-zinc tariffs were in the spotlight and introduction of the new plan covering five commodities caught many off guard. It was quickly recognized that, because of the new plan, the tariff recommendations probably would not be endorsed by the Administration.

After a short mulling-over period, many producers began to denounce the White House plan, some attacking it violently. "Mr. Seaton failed to explain," complained one, "why the Administration at the last session of Congress proposed a peril point price of 17¢ a pound for lead and 14½¢ a pound for zinc and now suggests a stabilization price of 14¾¢ for lead and 12¾¢ for zinc. This amounts to a reduction of 15 pct in the peril point price for these metals Mr. Seaton proposed last year."

A mining state senator commented, on first perusal, that the stabilization prices looked "too low and not realistic enough."

Most of the first commentators saw little merit in the program, but some of those interviewed indicated a hope that the revisions expected before legislation was put in final form would put the plan in a different light.

Others took a dim view of the entire proceedings. *The Wall Street Journal* bristled in an editorial tagged, "Fun for Bureaucrats." Opposed to the strategic stockpile, it jibed, "this plan at least has the virtue—if that is the word—of being a clearly-labeled handout."

"One trouble with such schemes is the fact that bureaucrats cannot arrive at a sensible price which is different from the market price," it continued, "so they inevitably distort the market and thereby postpone the corrections which are necessary in the industry they are supposedly helping. Another unpleasant feature is the willingness of supposedly free enterprises to let the Government put them on a dole."

But for most producers, the prime criticism was that the plan did not do enough. Many thought the stabilization prices too low and others thought the entire scheme dangerous. One commented that the plan would do no good if domestic demand did not pick up—producers would dump their material overseas and disrupt the entire world market by undercutting the foreign producers.

Some spokesmen, like Andrew Fletcher, president of St. Joseph Lead Co., called for quick action on Tariff Commission recommendations for higher levies, "especially as the industry followed the wishes of the Administration to seek relief under the escape clause provision of the Reciprocal Trade Agreements Act." He said the new plan seemed a temporary expedient and noted that "Congress must appropriate each year the amount of subsidy needed, even though Secretary Seaton said that the plan is for a five-year term."

Another criticism centered on the lack of price floors in the program. Secretary Seaton, however, expressed the belief that producers would not cut prices indiscriminately because of the force of public opinion against such moves.

A lead-zinc company official spoke for many when he declared the industry does not want to live off subsidies. Instead, import quotas would permit a permanent industry, he said.

The subsidy plan was also attacked outside the metal industries directly affected. R. S. Reynolds Jr., president, Reynolds Metals Co., objected that it "discriminates against the aluminum industry" which is in "daily and vigorous competition with copper, lead, and zinc."

Stripping overburden at iron ore mining operation near Greenville, Ala., this Caterpillar D9 Tractor with No. 9S Bulldozer "pushes more dirt than any other piece of equipment I have ever seen," says Owner J. Bryce Smith.

Caterpillar-built "track team" produce 100 carloads a week

J. Bryce Smith, owner of the Smith Mining Co. of Luverne, Ala., will tell you he has a winning Cat-built "track team" at work on his iron ore strip mining operation near Greenville, Ala. Here's what he says:

Cat D9 Tractor with No. 9S Bulldozer—"With the 'dozer it will push more dirt than any piece of equipment I have ever seen."

Cat D6 Tractor with No. 6A Bulldozer—"Although we've put more than 5,400 hours on it, the head and pan have never been removed. It has just as much power as when it was a month old. This machine has long since paid for itself."

Cat No. 977 Traxcavator—"We use it for a variety of jobs, and it does all types of work well."

Completing the team are a powerful Caterpillar D8 Tractor with No. 8S Bulldozer and several Cat Engines driving pumps for the iron ore washing plants and powering a shovel. Average overburden is eight to ten feet, and as deep as 25 feet. The company is shipping an average of 100 carloads of iron ore per week from Greenville.

High production like this—with minimum operating expense—is what mine owners everywhere get from modern Caterpillar-built equipment. The 320 HP (flywheel) D9, for example, handles about 12 cu. yd. on every pass with the No. 9S Bulldozer. Despite its massive size, it is one of the easiest of all tractors to operate because of power-boosted controls and excellent visibility. It's available with either torque

Operated for 5,400 hours, this Cat D6 Tractor with No. 6A Bulldozer has the same power it had when it was a month old, according to Mr. Smith. "It has long since paid for itself," he says.

This Caterpillar No. 977 Traxcavator, here seen loading out overburden, is used for many different jobs on the Smith Mining Co. operation. "It does all types of work well," Mr. Smith reports.

helps Smith Mining Co. at iron ore strip mine

converter or direct drive with the exclusive Caterpillar oil clutch.

The versatile No. 977 is typical of the Traxcavator line. It's built from the ground up as an excavator-loader. About 26 sq. ft. of ground-gripping track provide tremendous traction to crowd the 2¼-yd. bucket full every time. Controls are easily reached from the operator's comfortable seat.

These are just a few of the star performers on the Cat-built "track team." Get the full story on them from your Caterpillar Dealer. He'll prove the dollars-and-cents value of his track-type equipment in mining operations, demonstrate on your job. And he stands ready with *dependable* parts and service.

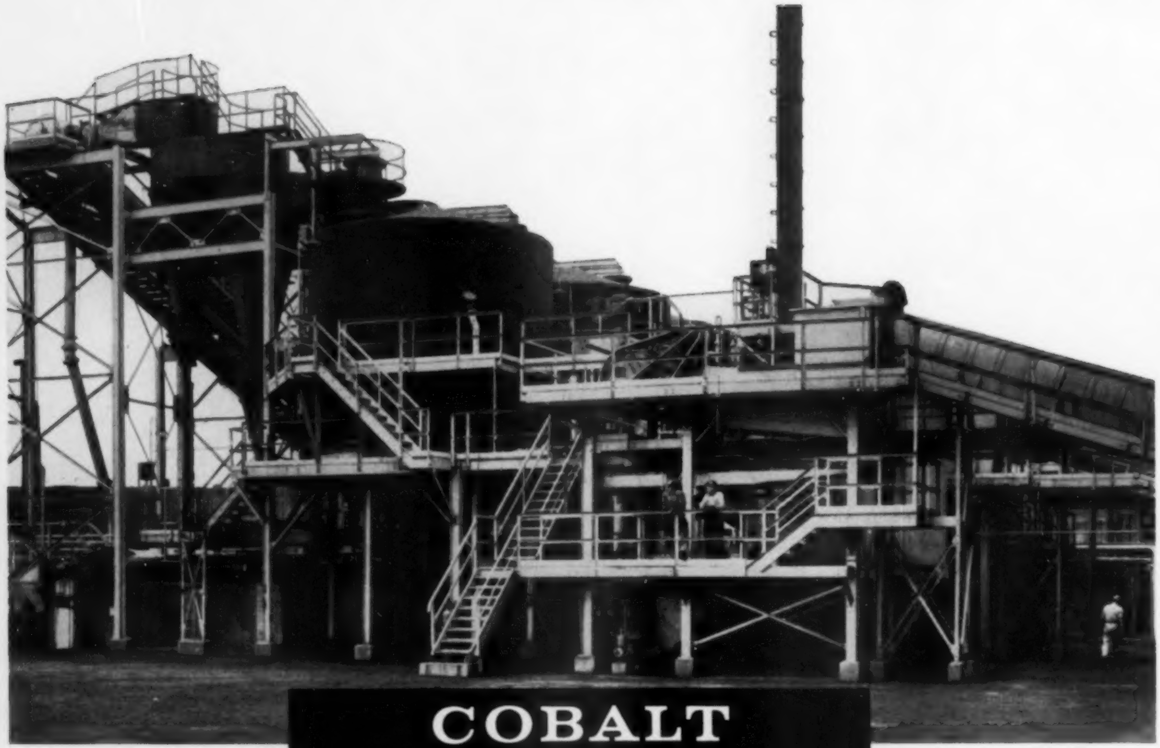
Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR

Caterpillar, Cat and Traxcavator are Registered Trademarks of Caterpillar Tractor Co.

LEADING "TRACK TEAM" FOR MINING

LOOK FOR YOUR CATERPILLAR DEALER IN THE YELLOW PAGES



COBALT FROM PYRITES

Versatile Dorrco FluoSolids System adds another "plus" at East Coast mill

Installed in 1952 primarily for production of SO_2 gas for acid making and a calcine for iron manufacture, the Dorrco FluoSolids system at a well known East Coast steel mill gives proof of the versatility of the fluidizing technique.

Pyrite received by the mill from one source of supply has a valuable cobalt content. A single roasting operation not only promotes efficient preferential cobalt sulfatization that results in an average 90 percent cobalt extraction at the leaching plant, but also produces SO_2 in sufficient strength for sulfuric acid manufacture as well as calcine for blast furnace charging. The success of this operation, never before attempted in commercial practice, is an outstanding example of the many processing opportunities offered by the Dorrco FluoSolids system.

The installation at this plant consists of three 18′ diam. reactors with pulping and holding tanks, cyclones and other auxiliary equipment. Currently one reactor is used to handle the cobalt-bearing concentrate.

Applications of the Dorrco FluoSolids system in other industries include arsenopyrite gold roasting, zinc concentrate roasting, providing a sulfating roast for copper-zinc concentrates, roasting sulfides for making cooking liquor in sulfite paper mills and limestone calcination.

If you'd like more information on this significant advance in roasting techniques, write to Dorr-Oliver Incorporated, Stamford, Conn.

DORRCO

DORR-OLIVER
INCORPORATED
WORLD - WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U. S. A.

MINING engineering

DRIFT

Education and The Challenge of Mineral Engineering

Engineering education . . .

We commend to your close attention the *Symposium on Mineral Engineering* beginning on page 669. These men (from both industry and education) are not talking to themselves, nor about themselves and *their* problems. They are talking about all of us. The speakers avoided the usual pitfalls and got to the roots of the problems that lie *outside* the college or university campus: the primary and secondary schooling that determines the preparation of the men to be trained; and the needs of the industry that takes up its training process where formal education ends.

We particularly commend to your attention the phrases used by Professor Spindler in the introductory part of the Symposium. Speaking of mineral engineering, he points out that it deals with "geologic vagaries and mass movements of materials that defy accurate prediction or quantitative measurement. . . (that mineral engineering) requires vision and the ability to apply engineering principles precisely without the convenience or proof afforded by mathematical analysis." We have never heard the paradox faced by those in the mineral industry stated more neatly: The problem of achieving engineering standards in an area that has as yet defied reduction to tabulation, equation, and formula.

Speaking to nonprofessional and lay groups about mining can be frustrating. It is deadly to begin a talk with definitions, yet start there you must, since the general public in many parts of the country has so little knowledge of the mineral industry. In searching for a means of differentiating the mineral industry engineer (including mining engineers, per se), one can point out that he has some training in the earth sciences. The degree of involvement varies from great for those in exploration, to little for those in beneficiation, but all have in common some underlying knowledge of the earth sciences. All are also concerned with one industry—the mineral industry.

. . . and the challenge of mining

Trying to explain what differentiates the problems faced by the profession is still harder. One item is the involvement with management, another is that all solutions must meet an economic test. But, heretofore, we have found it difficult to put in words what almost everyone in the industry feels. That this is a field where the engineer doesn't thumb a handbook for his solutions or crank his problem into an equation for a cut-and-dried answer. In mining engineering, and throughout mineral engineering, there is a challenge—to achieve engineering standards while dealing with phenomena that defy prediction and measurement. And, perhaps as a corollary, the challenge of moving the profession forward by reducing some of these phenomena to statistical prediction, if not quantitative measurement.—*R. A. Beals*

"Mineral Engineering—What Does It Mean?"
G. Ralph Spindler, West Virginia University
"Educating the Mineral Engineer"
H. V. W. Donohoo, Texas Gulf Sulphur Co.
"Five-Year Curriculum in Mineral Engineering"
D. H. Yardley, University of Minnesota
"Industry and Mineral Engineering Education"
Paul C. Henshaw, Homestake Mining Co.
Summary of Discussion at Symposium
Discussion recorded by Donald O. Rausch
"The SME Education Committee and Its Future"
Milton E. Wadsworth, University of Utah

A Panel Discussion

Mineral Engineering Education—Its Challenge and Its Future

This symposium is based on material presented at the AIME Annual Meeting in New York, February 1958. Co-Chairmen of the panel discussion were Truman H. Kuhn, Colorado School of Mines, and J. E. Monroe, Freeport Sulphur Co. Panel members are listed above.

In opening the meeting Chairman Monroe pointed out that both industry and education have their special problems and that the purpose of this and similar discussion groups is to bring together members from both industry and education in order to help solve their problems.

Mineral Engineering—What Does It Mean?

Summarized from the report by G. Ralph Spindler

Mineral engineering as a broad classification covers a number of specific fields of professional specialization represented by the various Divisions of AIME—Geology, Mining, Minerals Beneficiation, Petroleum, and Metallurgy. Its functions and services to society involve the entire range of techniques and scientific principles related to discovery, extraction, and processing up to, and at times overlapping, the final utilization or fabrication stage.

Mineral engineering is a distinct professional field in all its branches. It is not something acquired as a veneer—developed from the mere circumstance of employment and exposure to occupational environment—that can be readily superimposed upon any background of general or specialized engineering training. Mineral engineering begins with a basic interest in the problems and processes of minerals discovery and exploitation, supplemented by special training in the principles and technologies involved. Without the continued stimulation of that special interest, no amount of training or employment experience will produce a mineral engineer in the true sense. That is not to say that someone with engineering training in other specialized fields may not become a good mineral engineer, but usually even casual shop conversation with such people reveals that their interests and thinking have become channeled very specifically to the problems and technologies of mineral engineering, with a definite submergence of their original professional training.

Those fields of mineral engineering concerned with discovery and exploitation of mineral deposits have certain characteristics: They quite commonly deal with geologic vagaries and mass movements of materials that defy accurate prediction or quantitative measurement. Such circumstances require vision and the ability to apply engineering principles precisely without the convenience or proof afforded by mathematical analysis. Errors can be costly in dollars and human life and it takes good judgment, combined with confidence and courage, to sponsor a departure from a conventional practice in underground mining.

There are few fields of engineering specialization that are generally so closely integrated with the problems and processes of management. Costs, quality control, markets, personnel management, job training—all these and other factors must be considered in just about every problem or proposition relating to exploitation with which the mineral engineer is concerned. Deficiencies in technical ability or the capacity to work with people at all levels may be conspicuous.

What is the position of the mineral engineer in society and in our industrial future? In effect, he is the custodian of the world's mineral resources, which are the basis for a large part of our material wealth and industrial production. Conservation is a moral, technical, and economic responsibility of the mineral engineer, and his position is one of public trust.

For the most part, he remains in the background, as far as the public is concerned, in the parade of industrial developments. Yet many of the day-to-

day contributions of the chemist and chemical engineer to the list of products that add so much to the health, comfort, and convenience of mankind represent just another aspect of fabrication of base materials made available through discovery and exploitation of mineral resources. A sensational new development catches the public attention, but few people recognize that almost every advance in such glamorized fields as jet propulsion, nuclear processes, missiles, and even the earth satellites has been preceded by the equally sensational but commonly unheralded accomplishments of the metallurgist.

These are some of the characteristics that identify mineral engineering as a distinct field involving specialized training in related sciences, combined with the special personal aptitudes and interests of its membership.

Educating the Mineral Engineer

Summarized from the report by H. V. W. Donohoo

Since Sputnik No. 1, education—and especially science and engineering education—has been a most popular and urgent subject. Obviously the remarks that follow must be made against this background. The challenge and the future in educating engineers today, both mineral engineers and others, lies in increasing the efficiency of the system to produce more engineers and better ones. The end point for us is to find and exploit the minerals and discover processes for making mineral products economically available.

In defining the term *mineral engineering* this fundamental purpose should not be overlooked. University training beyond the bachelor's degree is traditionally in research, a useful tool for both scientist and engineer. But whether a student pursues his college training four, five, or seven years, he becomes an engineer only after demonstrating that he can apply this background to the needs of man and do it economically. Without by any means deprecating advanced degree work, these remarks will be confined to the challenge of increasing the efficiency of training through a four-year college course.

Role of the Public Schools

Since the 1930's the literature of our society and the minutes of mineral engineering education committees have pleaded for improvements in pre-college training. The effect has been negligible. But Sputnik has accomplished what might have been considered impossible in these councils last year. Fear has taken ascendency over desire for convenience and comfort. The challenge, then, for us all is to take advantage of this new popular trend to promote rigorous and traditional education in the public schools.

What, specifically, can the universities and colleges do to insure that college candidates will be better prepared? The writer believes the colleges have it within their power to insist on suitable high school pre-college training. The social prestige of a college degree is very high in our land. The college curriculum can be so redesigned that it will become a social necessity for high schools to provide the proper prerequisites for those desiring to attend college. A start might be made almost immediately by sending students back to high school or junior college to make up prerequisite course requirements, or by supplying, on the campus, non-credit prerequisite courses. It is more efficient to extend the time of pre-college training than to go to five and six-year undergraduate courses.

Here are the high school requirements we desire for the engineering college applicant:

1) Mathematics including trigonometry, advanced algebra, and introduction to calculus.

2) Introduction to chemistry, physics, and biology.

3) Rigorous training in English and perhaps foreign language.

4) Suitable studies in history, civics, and economics.

Such a program would mean shifting responsibility for less academic training downward to the junior high schools, to extracurricular activities, and to the home. Most people will agree that our public school age children are *not* now adequately challenged nor their talents efficiently exploited. It has been said that it is necessary only to give a student an exciting goal to find out what an amazing talent for accomplishment the human being has. Obviously, if the education system is to be improved, young students and their parents will have to be convinced that it is all worthwhile.

It now appears that this improvement may soon take place. This will provide the greater number of qualified candidates now required. It will loosen the strait jacket binding four-year college curricula. It will permit streamlining engineering education. A startling increase in the overall efficiency of engineering training should result.

Enrollment in Mineral Engineering—Quality vs Quantity

The choice of mineral engineering as a career should be presented early in high school, along with other vocational guidance, in proportion to the importance of the mineral industry in the overall economy. This might be a principal concern of the AIME Council on Education, which represents both mineral education and the mineral industry.

Current publicity indicates that there is a great shortage of engineers and that we are losing the technology race because Russia is out-producing us in this field. But quality rather than quantity is probably more important in this international race. It would be very unwise for the free world to follow Russia's reported arbitrary allocation of students to each field in accordance with some master plan and student test. Artificially created demand resulting in over-production of engineers beyond the number required by society would lower the professional quality of engineers. This could easily lead to unionization, under which the law of supply and demand normally administered by free enterprise is amended by Government and organized labor. The responsibility of the college is to produce

highly qualified engineers. Industry and society will have to provide the incentive in wages and prestige to attract the proper numbers to the field.

Many committee curricula recommendations have been criticized because they stress the "desirability of the student having all applicable knowledge." A practical compromise in the ASEE report, *Evaluation of Engineering Education*, is used as a basis for accreditation by the ECPD. But many schools have found it difficult to include these requirements adequately in four years. The improved preparation of the entering freshmen and the resultant possibility of streamlining college courses should make it much easier to realize these standards.

Basic science and engineering courses can be taught from a more advanced viewpoint, eliminating such repetition as exists between physics and engineering mechanics. In each successive course the fundamentals of former courses must be re-applied to develop advanced concepts. One criticism made by the ECPD accreditation committee of certain senior courses is that they have been taught with freshman rather than senior prerequisite background.

Almost every questionnaire submitted to industry comes back with the comment: "We wish our engineering employes were better grounded in fundamentals of English, mathematics, science, and engineering." Apparently this is sometimes taken to mean that more of these subjects should be crowded into a four-year program and that the specialized courses should be deleted. A more realistic interpretation is that industry is not calling for *more* training in fundamentals but *better* training, so that fundamentals can be retained and used in a special field.

The writer is led next to discuss the balance of the curriculum between science, engineering, social studies, and specialized engineering courses. This includes the following much debated subjects—science vs engineering, fundamentals vs specialization, *know-why* vs *know-how*. What is their relative importance in mineral engineering education?

Engineering subjects require science subjects as background, but this does not mean that engineering subjects can be neglected. Specialization requires fundamentals, but this does not mean that an engineer can perform properly in this age of diversified knowledge without adequate specialization. *Know-how* requires *know-why*, but an engineer's *know-why* is absolutely pointless without ability to perform. The engineer must have skills in English and mathematics for communication and problem solving and skills in fundamentals and science for understanding, analysis, and design; but also he must have know-how in data collecting, graphical representation and mapping, surveying, building, handling equipment, and—especially the mineral engineer—skill in working hand-in-hand with Nature. He must also have economic foresight in seeing a project through to practical completion—one area in which American engineers are justly noted.

In the search for unknown and buried mineral deposits a man who cannot effectively use field equipment for data gathering or *trouble-shoot* an equipment failure does not get the job done, no matter how good he may be in proposing various mathematical models to explain poorly collected data. The success of exploration design and analysis is in discovery of economic minerals. This requires a feel for practical field conditions and the methods of collecting and representing suitable data. To eliminate *know-how* and specialization from mineral engineering curricula tends to eliminate economics from the definition of *engineer*.

Summary

In summary, then, there is a challenge to mineral engineers to urge more rigorous standards for college candidates in high schools and more vocational guidance in the mineral field.

There is a challenge to colleges to establish suitable entrance prerequisites so that college curricula can be streamlined. If necessary, pre-college time should be extended. In the colleges themselves curricula should utilize more effectively the fundamentals of previous courses.

There is a challenge to produce quality engineers rather than to over-produce mediocre engineers. Industry and society must provide the incentives.

Finally, although fundamental general studies are essential to the *man*, specialized studies and *know-how* are essential to the *engineer*.

Five-Year Curriculum in Mineral Engineering

Summarized from the report by D. H. Yardley

Any course, no matter how specialized, should develop its major purpose within a more general context. College students usually get much more from a good teacher than subject matter, and an engineering teacher's influence should provide more educational residue than easily forgotten factual information.

At the University of Minnesota three expedients to improve professional degrees in mineral engineering were considered:

1) Higher entrance requirements, so that university work could start at a higher level.

2) Increased work load during the four-year program.

3) A five-year program.

Higher entrance requirements do not seem feasible for some time to come, for the college or university must start where the high schools leave off. The trend towards more science and engineering science hardly permits a decrease in those subjects in order to make room for more liberal arts courses, for mineral engineering curricula in general already require a heavy work load.

The University of Minnesota wanted to add whatever might be necessary to attain a more truly professional training, but not at the expense of the engineering instruction, for a professional engineer must first of all be competent within his field of specialization. It was believed that both could not be accomplished within a four-year period, and the

Four and Five-Year Plans Compared

Five-Year Curriculum

Sciences: Mathematics, physics, chemistry, geology	Engineering Sciences	Mining Engineering: Includes 15 credits of ore dressing
96	62	55
	Total technical area	213 Credits
	Required English	15
	Other liberal arts	21
		250 Credits
	Not included in above are field courses:	
	Mine and mineral land surveying	6 Credits
	Mine inspection and report	6
	Geology field trip	3
	Total requirements	265 Credits

Mining Engineering, Four-Year Curriculum

Sciences	Engineering Sciences	Mining Engineering
83	74	44
	Total technical area	201 Credits
	Required English	9
	Public health	3
		213 Credits
	Not included in above:	
	Mine surveying	6 Credits
	Mine inspection and report	6
	Geology field trip	3
	Total requirements	228 Credits

faculty finally agreed to a five-year curriculum for all engineering students.

Here it should be pointed out that a considerable number of students in four-year schools require more than four years to complete all degree requirements. Some courses are offered only once a year, and the heavy regular class load makes it difficult for an average student to pick up an extra course. A study showed that the average time for engineering students at Minnesota to complete the four-year course was 4.7 academic years; under the five-year plan the time is approximately 5.2 years. Thus the average student requires only half a year longer to obtain five-year training.

A five-year program has permitted decreasing the work load in the latter part of the senior year so that a student who is deficient in a course or two can schedule it without compounding his problems.

There have also been some benefits not fully anticipated. Transfer students have more time to pick up courses that conflict with other required courses because of schedule irregularities. There is more flexibility in scheduling terminal courses, which may be given in either the fourth or fifth year.

The courses in the liberal arts area are roughly equivalent to one year of arts. In the freshman year Minnesota's engineering school now has a full year of English of 3 hr per week. In 1959 this will be increased to 4 hr per week and will be identical to the English given in the liberal arts college. The upper 5 pct (in English) of the students may substitute a year of advanced English or foreign languages. No further English is required until the senior year, when two further English courses are required. This does not include geology reports and the senior mining thesis where training in report writing enters in. In addition to the basic English courses the engineering school requires 6 credits in each of three general fields: 1) natural science, psychology, botany, or zoology; 2) economics, politics, sociology, or social science; 3) English, history, religion, or the humanities.

The remaining required credits may be taken anywhere in the above fields or in other liberal arts fields such as classics, geography, astronomy, languages, speech, and literature.

It has been possible to increase the amount of work in the science and engineering fields. The total of non-technical credits is now about 45, including English and 6 credits of the total geological requirements. The added non-technical courses actually total about 30 credits, but as Minnesota's average is 17 credits per quarter, additional engineering credits have been obtained as well.

An increasing number of companies now recognize the five-year degree by paying a five-year man as much as a Master's degree man if the Master's candidate took only a four-year course previous to his graduate work. The average starting salary of Minnesota's engineering graduates was $492 per month in 1957. The average for four-year engineering schools in general was a little less than $470. Such figures demonstrate that industry prefers a five-year degree.

A special problem in a five-year curriculum is the student with potential for graduate work. Minnesota permits a student to apply for a B.S. degree without designation at the end of four years. If he has mainained a "B" average and is accepted for graduate work, he then follows a program determined by his adviser. This enables the better student to take special courses and obtain a Master's degree in about five and one-half years.

The accompanying table compares Minnesota's former four-year requirements with the University's present requirements.

The differences are somewhat greater than the figures indicate. For example, mineralogy used to be 10 credits and now is 8 credits for the same coverage. Surveying was 17 credits and now is 15 credits but covers the same areas. In several other cases the credit allowed is now less but the lecture hours have not decreased.

Industry and Mineral Engineering Education

Summarized from the report by Paul C. Henshaw

1) Industry expects an engineering graduate to be competent in his own field, to have in addition a basic knowledge in the fields of science, English, economics, and human relations, and to be versatile in other related fields.

2) It is difficult in a four-year mineral engineering education program to cover adequately all fields expected by industry.

3) The graduate should be alert to problems outside his field.

4) Diversification as opposed to specialization in a curriculum is a difficult problem to solve, but it must be brought to favorable balance. Minnesota's five-year curriculum may be a proper approach.

5) The high standards expected by industry are not merely brand names; nevertheless, these standards should be used to drive the students. Drive the student long and hard so that he will learn to drive himself.

Summary of Discussion

From discussion recorded by Donald O. Rausch

It is difficult to cover all requirements adequately in a four-year mineral engineering education program that includes diversification as well as specialized subjects. Minnesota has shifted to a five-year program leading to a degree in Mineral Engineering, but this degree does not include the men in minerals beneficiation. Similar degrees are given in Canada.

The five-year program, however, is an admission that pre-college training is poor. Perhaps some of the public schools should examine the pre-academy training carried out at Annapolis and West Point.

It is argued that the degree of attainment expected by industry should be used as an incentive for college students. Tighten up college standards; if necessary, fail upperclassmen.

But mineral engineering's rewards are not commensurate with the qualifications it demands. In this respect it cannot compete with the chemical industries and other more glamorous and profitable fields. After four years of developing a cultural background in college, the graduating engineer is placed in a remote area barren of cultural activities. Mining companies need more than recreation halls and bowling alleys; they need facilities to interest these people with advanced education.

The industry also makes the mistake of assigning the engineering graduate non-technical work only, such as drilling and mucking. This is all right for a time, but not over a long period. A newly hired geologist is usually put on sampling; in foreign countries this is generally done by a boy, and the job does not require even a high school education. The same is true with mine surveying. It takes only a man with a high school education and two weeks of vocational training to make a competent mine surveyor. Surveying has been dropped from the mining curricula in California and only a few days are spent on it in another course.

Finally, the industry should offer reasonable security during periods of economic recession. Even though mangement is usually under pressure from stockholders to economize during a decline, exploration should be continued, for operations are cheaper at this time.

Discussers: H. V. W. Donohoo; S. E. Gluck; P. C. Henshaw; J. E. Monroe; L. E. Shaffer; T. C. Shelton, Jr.; G. R. Spindler; D. H. Yardley; Dr. Cook; Mr. Morgan.

The SME Education Committee and Its Future

Summarized from the report by Milton E. Wadsworth

The organization and objectives of the Education Committee of the Society of Mining Engineers were pointed out in article VII, Section 7 of the bylaws under the recent reorganization of the AIME. These bylaws authorize four members minimum for the committee plus a chairman, these members to be appointed from each of the four divisions of the Society of Mining Engineers. The objectives of the Education Committee as delineated in these bylaws are:

1) to represent the society in all matters concerning education in the mineral industry,
2) liaison between divisions, the Society, and the AIME council for Education, and
3) responsibility for instituting positive and constructive programs for improvement in all phases of academic and professional education for the mining engineers.

This was the premise for the initial work carried out by the engineering committee in 1957. On April 22, 1957 the first meeting under Professor Pfleider, Chairman of the Education Committee, was held at Golden, Colorado. As a result of this committee meeting, several motions for reorganization and objectives were suggested. These were drawn up by Professor Pfleider and submitted to the President of the Society of Mining Engineers for action. These suggested motions were as follows:

1) The organization of the Education Committee should be expanded beyond that suggested in the bylaws to provide adequate representation over the broad fields of interest within the divisions. It was therefore suggested that the committee be made up of the chairman plus 12 members, 8 members from areas of education and 4 members from industry; 3 members, therefore, representing each division.
2) The publication policy of the Society of Mining Engineers should be critically reviewed, particularly towards liberalizing presentation of research and scientific papers. It was felt that it is the responsibility of the educational institutions to initiate and foster research, and it is also the responsibility of the professional society to disseminate this information throughout the world.
3) Regarding ECPD accreditation it was suggested that the maximum tenure of office of AIME ECPD representatives be three years. Further, that the council of education should contact the Board of Directors Education Committee of the Society of Mining Engineers for suggestion on the selection of ECPD representatives. Also, it was recommended that only one visit by an ECPD representative be permitted and that subsequent visits be carried out by other ECPD representatives. Anyone selected to carry out such accreditation should be specially qualified in the particular area in question if possible.
4) It was suggested that some effort be directed toward greater cooperation between groups having parallel education interests. Such an effort was suggested in cooperation with a group of Mining Engineering Educators newly formed under the direction of Professor Spindler, West Virginia University, Professor Parkinson, Colorado School of Mines, and Professor Schaffer, University of California.

Following the submission of the resolutions suggested in the April 22 meeting, 1957, a board meeting of the officers of the Society of Mining Engineers was held May 10, 1957, under the supervision of Elmer A. Jones, President. It was agreed at that time that the Society of Mining Engineers Education Committee would be revised as far as organization is concerned in accordance with the resolution passed April 22, 1957, in Golden, Colorado.

Cross Section of Opinion

Comments were solicited by Professor Milton E. Wadsworth from several men in the field. The suggestions for the future of the Education Committee contained in these letters are summarized in the following paragraphs. Professor Wadsworth has divided the comments into six general categories.

I. Curricula (Revisions and Accreditation)

1. Make curricula studies with a view to broadening engineering curricula, requiring fewer trade courses. Most companies have newer techniques than the colleges and prefer to teach them to recruits without their having to unlearn outdated ideas. There should be more depth in basic science, humanities, and social science, which makes for good executive material.

2. Recent nationwide concern about the deficiencies of U. S. education has prompted over-hasty re-evaluation. There has probably been too much attempt at standardization and too much broadening of curricula. We should proceed slowly.

3. The Committee should establish an annual symposium on mineral engineering curricula, with specific emphasis in the particular divisions of mineral engineering.

4. The Committee should investigate to ascertain if there is a tendency of ECPD to use accreditation:

(a) As a means to standardize the various mineral engineering curricula. Not all engineering colleges should have to teach all phases of human education; the individual colleges should be able to develop their programs to fit their particular goals.

(b) To broaden engineering curricula so much that they are no longer engineering. Although engineering is primarily an applied science, it does not altogether follow that engineers need only learn the basic sciences to be able to apply the principles; they must be trained to apply them, and a specific curriculum should offer the opportunity to weigh theory with practicality.

5. There is considerable divergence in mining, extractive, metallurgical, and geological curricula at the various mining schools. Possibly a representative of each school could, in turn over the years, describe the specific curriculum at his school and defend it against any who have different views.

6. There should be a general discussion of the relative value of additional basic science courses at the expense of laboratory and field work.

7. We are well informed of the reasons against the five-year course, but many believe we are approaching or have passed the time when a five-year engineering course is more desirable than the present crowded four-year course. What are the chances of a general discussion on the subject which might result in all accredited mining schools agreeing to the five-year program?

II. Corrective Measures for Grammar Schools and High Schools

1. Develop student interest in high school and even in grade school by company and college exhibits, speakers' programs, films, and especially TV programs.

2. Collect and publish a bibliography of engineering fiction and non-fiction for the 8 to 16-year olds, to be distributed to high school science teachers and local libraries.

3. Since the Government and public are conscious of the weakness of science education in high schools and many engineering schools, the Committee should use its influence for improvement by circulating mimeographed or printed suggestions to the various schools.

4. An article in the Sunday *New York Times Magazine* of Jan. 26, 1958, makes timely recommendations to the College Admissions Board: Temporary increase of subject matter for admission to colleges should be brought to 3½ years of English, 2 years of mathematics, 1 year of science, and 2 years of a foreign language. Subsequently, admission requirements should be 4 years of English, 4 of foreign language, 4 of mathematics, and 3 of science subjects. Students are now being admitted and graduated even from state universities without having gone beyond 7th grade arithmetic. Such people are not necessarily being admitted to chemistry and engineering departments but do receive degrees in education and liberal arts. As mentors for future engineers and chemists they should have more adequate training.

5. Today only the private schools offer adequate preparation for college, since public schools have been completely subjugated to mass education.

6. The Education Committee's first responsibility is to make clear that students who will be capable of entering and finishing in the field of mineral engineering must have the minimum course work that is required as a future standard of the Board of Admissions. Present curricula in most engineering schools have been carefully analyzed by the Committee on Professional Engineering Education and those that have been certified continue to maintain their high standards. Uncertified schools are making every effort to raise their standards so they can receive certification. But schools cannot work with students who come to them poorly prepared.

III. Cooperation Between Industry and Education

1. Educate the industry to the fact that unless it can pay engineers on a scale equal to the wage scale in other professions it is going to be behind. (Oil companies excepted; mining companies, please note.)

2. Enlist industry support for research, scholarships, and fellowships by sponsoring closer relationships between educators and industry representatives. Management in the coal industry is especially backward about keeping contact with high school and college faculties. College faculties in turn could well afford to maintain at least some contact with high school principals, counselors, and teachers of science and mathematics. The Committee should outline a plan for the colleges to develop closer contact with the schools on one hand, and industry on the other.

3. The breadth of such an education committee and the impact it can have upon the future education of engineering students can either be very great or very insignificant, depending entirely on acceptance by the colleges of the viewpoint of both educators and the end users of the product of education.

IV. Financial Assistance for Students

1. Partial subsidy of education costs in mineral engineering would attract more students to the field and would enable students now holding part-time jobs to devote more time to their studies. Commercial concerns in the mineral industry might be induced to contribute annually to the AIME scholarship fund or to a revolving loan fund. Grants from the former should probably be awarded on the basis of competitive examinations if these are available to entering students. Those already in college can be judged by their scholastic performance to date. Grants from a loan fund might be made available to students of sound character and promise, even though not of honor grade. Financial help is particularly needed to enable more students to attend summer field camps.

V. Role of Committee in Promoting Cooperation Among Educators

1. To assist educators in mineral engineering to maintain contact with each other through the media of meetings, visiting lectureships, and a good directory.

2. To develop and support ideas of mutual use—new concepts, new textbooks, laboratory manuals.

3. To stimulate and sponsor subcommittees in specific areas, such as the subcommittee for Mineral Engineering Educators. These subcommittees may be a part of either the education group or specific to the division, such as the Minerals Beneficiation Division or the Industrial Minerals Division.

VI. Research

One of the responsibilities of schools of higher learning is to carry out fundamental research. Emphasis is greatly lacking in this area. The long-range effects of basic research cannot be over-emphasized, and the accomplishments of the past point up the need for more. It should be a primary objective of the Education Committee to direct attention to basic research, both in print and by oral presentation at national meetings. This may well be extended to the Society of Mining Engineers and eventually to the AIME in general.

These objectives outlined by contributors indicate general interest in formal education: What can be done about engineering curricula? What can be done to improve the caliber of students coming into college? How can we encourage students to enter the various branches of mineral engineering? How can we stimulate quality and quantity in the presentation and development of fundamental research. In what ways can we encourage cooperation between educators and industrial representatives, so that we may be more aware of the problems in common?

These problems and many others face us as individuals and as parties of common interest, but there is also a moral obligation to improve quality as well as quantity. In view of the world situation and the declining quality of mineral deposits, present needs demand concerted and directed effort to improve minerals development in all categories. It is certainly to the interest of the Education Committee and the Society of Mining Engineers to promote these objectives.

MINERAL X

Economic Evaluation of an Industrial Mineral Project

by J. E. Castle

THE title of this article is descriptive, but not complete, for psychological evaluation is almost as important as rigid economic evaluation. This refers to those human traits that cause people to be too optimistic about the projects they are sponsoring, to overlook obvious weaknesses, to base decisions on incomplete and inaccurate data, and to gloss over embarrassing problems.

Investment of capital in a new industrial mineral project is warranted only after rigorous economic analyses based on unquestionable facts. A plunge into production cannot be justified solely because these minerals have been deposited in the ground and are therefore free. There are no specially favorable economic laws that make the business of industrial minerals more attractive than any other. The factors of supply and demand, marketing, technological changes, taxes, competition, and fluctuating prices apply as much to industrial minerals as to other business enterprises. What is more, industrial minerals are subject to the higher risks that all mining enterprises face.

The first rule of economic evaluation of industrial minerals is to make a quick check of pertinent facts to determine whether a complete evaluation should be made. To exaggerate, if the Gulf Coast market is to be reached, a barite deposit in interior Alaska can not be made competitive with barite deposits in Arkansas, simply because of transportation costs. A second type of project will be easily eliminated if mineral land owners demand a purchase price or royalty so high as to make profits doubtful or impossible. In a third instance, non-professional or incompetent principals may load a mineral project with such capital costs as to make it unprofitable to them or to prospective buyers.

J. E. CASTLE is Manager, Industrial Minerals Div., International Minerals & Chemical Corp., Chicago.

Case History of Industrial Mineral "X": Since the market for the industrial mineral itself is the most important factor, this discussion will start and finish with the market for mineral *X*. Conditions are most favorable when the market for *X* is expanding and price is generally rising. If the market is stable, there is another set of conditions—not so favorable. If the market for mineral *X* is actually shrinking, conditions are least favorable, and unless some very unique circumstances can be found, it is best to forget *X* and investigate *Y*. Do not forget the present producers of mineral *X*, since they will not stand idly by and watch someone usurp part of their market. Next, do not assume that mineral *X* is so unique in its properties that its market is everlasting and an economic substitute cannot be found. The world is full of aggressive and enterprising people who are continually seeking an economic substitute for mineral *X* and for every other com-

Case History of Mineral X

These figures are not from a case study and were chosen to illustrate the method.

Estimates of Capital Requirements for Industrial Mineral *X* Project

Plant Capacity: 100,000 tons per year

Fixed Capital		
1. Mineral land purchase, including prospecting, drilling		$ 200,000
2. Quarry development costs		50,000
3. Process development costs, market studies		80,000
4. Land and equipment		
Land	$ 55,000	
Water supply	35,000	
Railroad spur	55,000	
Tailings disposal	80,000	
Mine plant	275,000	
Beneficiation plant	935,000	
Buildings	285,000	
Power station	35,000	
Engineering costs	200,000	
Total land and equipment		$1,955,000
Total fixed capital		$2,285,000
Working Capital		
1. Cash, 10 pct of annual sales		$ 300,000
2. Accounts receivable, 1/12 of annual sales		250,000
3. Inventories		225,000
Total working capital		$ 775,000
Start-up expenses		250,000
Total capital		$3,240,000

Estimate of Net Sales for Industrial Mineral *X*

Mineral *X*, Grade *A*, 10,000 tons @ $60 per ton	$ 600,000
Mineral *X*, Grade *B*, 30,000 tons @ $40 per ton	1,200,000
Mineral *X*, Grade *C*, 60,000 tons @ $20 per ton	1,200,000
Total net sales	$3,000,000
Average selling price—$30 per short ton	

Estimates of Manufacturing Costs for Industrial Mineral *X*

Plant capacity: 100,000 tons per year

Fixed Costs	
Depreciation and depletion at 10 years	$ 253,500
Local taxes and insurance	8,000
Fixed plant overhead	120,000
Prospecting	40,000
Minimum royalties	20,000
Total fixed costs per year	$ 441,500
Variable Costs	
Stripping overburden	$ 130,000
Mining	185,000
Hauling	150,000
Royalty	82,000
Fuel	135,000
Chemicals	310,000
Power and water	100,000
Labor, including fringe benefits	460,000
Operating materials and supplies	325,000
Miscellaneous costs	75,000
Total variable costs per year	$1,952,000
Total manufacturing costs per year	$2,393,000

Profit Estimates for Industrial Mineral *X*

Total net sales per year		$3,000,000
Total of fixed and variable manufacturing costs		2,393,000
Gross plant profit per year		607,000
Less: Selling expense 5 pct of sales,	$150,000	
Engineering and research expense 3 pct of sales,	90,000	
Home office expense 3 pct of sales,	90,000	
Total of expenses deducted from gross plant profit		330,000
Before-tax operating profit		277,000
Federal income tax @ 23 pct*		64,000
After-tax operating profit		213,000
Ratio of after-tax profit to total capital		6.6 pct
Ratio of after-tax profit to fixed capital		9.3 pct
Ratio of annual sales to total capital		0.93
Ratio of annual sales to fixed capital		1.26
Ratio of after-tax profit to annual sales		7.1 pct

* It is assumed that percentage depletion applies.

modity of commerce. Therefore, the investment in *X* must be recaptured in reasonable time. Perhaps most important of all, do not dwell too long on the f.o.b. price of mineral *X* as quoted in trade and technical journals. The more important figure is the delivered cost of *X* to the customers' plants. Differentiate between customers. Is mineral *X* to be sold to private industry? To a government agency? To a government stockpile for a limited period of time at guaranteed price? And what happens to the project if Congress fails to approve additional sums for stockpile purchases? A most important factor to consider is the effect of foreign competition. Finally, the effect of transportation on the competitive market pattern should be investigated. This means, for instance, that investment could not be justified in a project for mineral *X* in a foreign country where all factors are favorable except that transportation facilities are inadequate to move the commodity from the plant to a seaport. At the other extreme, again as an example, a competitor could find an excellent deposit of mineral *X* remote from the U. S. but very strategically located on or near the ocean front to take advantage of low-cost ocean freight to the U. S.

There will be more to say about the market later, but it is pertinent to mention here that an accurate survey is not made simply by a library search of production, consumption, and price statistics. To obtain the most up-to-date picture, as many producers and consumers of mineral *X* should be interviewed as possible, either by the company's market analysis department or by a professional marketing group.

Pitfalls in Production: Next, some practical aspects of production and financial analyses. It is now assured that there is a favorable market for mineral *X*. Is there a good deposit to exploit? A good deposit of mineral *X* has the following attributes:

1) Size and grade are competitive with those of existing producers.

2) A product with specifications demanded by the trade can be prepared for market at a cost competitive with that of existing producers.

3) Transportation costs from the mine to consumers' plants are competitive with those of existing producers.

4) Purchase price of mineral lands or royalty rates are competitive with those of existing producers.

If the total of costs enumerated above is higher than those of existing producers, be satisfied with a lower profit—or enter another business. Next to a very faulty market analysis, inaccurate estimates of these costs cause the greatest number of failures in industrial mineral ventures. It is not easy to estimate them, particularly the costs of existing pro-

ducers. Here are the most common sources of errors in estimating:

1) Incomplete prospecting and diamond drilling, leading to overestimation of quantity and grade of ore and underestimation of cost of mining plant and mining.

2) Improper sampling. This is particularly dangerous when a flotation beneficiation plant or a chemical plant is constructed on the basis of laboratory and pilot plant results obtained on ore samples *not representative of the ore to be mined.* Generally speaking, this is a failure to recognize that in a typical industrial mineral quarry or pit the mine sends clean ore, muddy ore, oxidized ore, wall rock, snakes, discarded clothing, and roots to the beneficiation plant, all of which is classified as *ore.*

3) Inadequate pilot plant studies, particularly where chemical and flotation processes are involved. Failure to make adequate translation from pilot plant size to commercial size, or failure to duplicate in the commercial plant the operating conditions found necessary in the pilot plant.

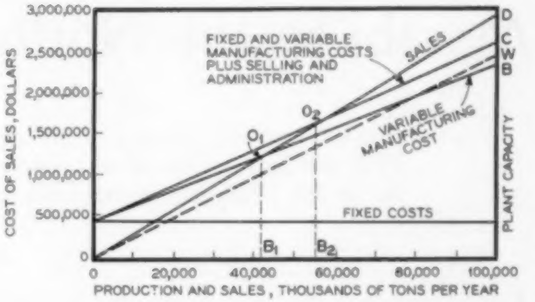
4) Failure to recognize the magnitude and duration of start-up costs. For a financially strong company this can be acutely painful—for a company not so well financed these costs can prove fatal.

5) Underestimation of start-up costs is paralleled by underestimation of the time required to reach volume sales. Unless a new enterprise is fortunate enough to have firm sales contracts with a government agency or large private customers, it is a long struggle to build up sales that will equal production capacity. During this time, one thing is certain—competitors will not be helping to attain the desired volume. In the meantime, the venture is sustaining losses because of failure to reach the projected break-even point at the time predicted.

At this point, assume that a favorable market survey has been made and a suitable ore deposit located. Now, how much capital is it going to require, what is the rate of return on capital, and what is the breakeven point? This does not imply that the producer has so far made no study of capital requirements. It is simply that this is the time for him to write down what he hopes are accurate figures based on the previously accumulated data. The reader's attention is called to the accompanying tables—Estimates of Capital Requirements, Estimate of Net Sales, Fixed and Variable Costs of Production, and Return on Investment.

It should be noted that in the table presenting net sales the selling prices of mineral *X*, grades *A*, *B*, and *C*, are not merely rough estimates but the result of monumentally complete market studies. The tendency to overlook some items of capital and costs should be carefully avoided. It is impossible to operate a mine and flotation plant without provisions for tailings disposal, water supply, machine shop, change houses, etc. A business cannot be run without cash, without accounts receivable, and without capital to finance inventories of crude ore and finished product and inventories of operating materials and supplies.

The arithmetical data in the tables are not taken from an actual case study and are presented solely to illustrate a method of calculation. In an actual case the accuracy of the study, and therefore its value, depends on the accuracy of each individual figure. For this reason it is vitally important to apply to consultants or to utilize fully the efforts of



geological, research, market, engineering, production, and accounting groups in the organization.

To return to the subject of marketing, refer now to the break-even chart for industrial mineral *X*.

Line *A* represents the fixed manufacturing cost; line *B* represents the total of fixed and variable manufacturing costs; line *C* represents the total of fixed and variable manufacturing costs plus selling and administrative costs; and line *D* represents net sales.

Two important points are identified, O_1 and O_2. Point O_1 is the break-even point before selling and administrative expenses, and point O_2 is the break-even point after selling and administrative expenses. Point O_1 is reached after production and sales have attained the rate of approximately 42,000 tons of mineral *X* per year, and point O_2 is reached at 55,000 tons per year. The triangle DCO_2 is the before-tax profit triangle. At any point beyond O_2, before-tax profit is equal to the vertical difference between lines *C* and *D*.

Now examine the sales line *W* (for wrong). This would be the case where the market analysis was inaccurate. Instead of a $30.00 average selling price, there is a $25.00 price. This could be brought about by inaccurate prediction of the various tonnages of different grades of product, or it could be the result of adding more productive capacity in mineral *X* than the market could absorb, or it may be simply that the competitors lowered their selling price to meet the competition and to hold their volume. Whatever the reason, it moves the break-even point, before selling and administrative costs, substantially upward to about 78 pct and, after selling and administrative expenses, substantially beyond 100 pct of plant capacity. The same poor results would of course be obtained by grossly underestimating fixed and variable costs of manufacturing, and certainly such underestimations have been an unhappy part of industrial minerals history. Nevertheless, the most likely reason for failure in any industrial mineral project is inaccurate market study.

There are many reasons why a market survey can be inaccurate—failure to make a comprehensive study, misinterpretation of consumption figures and of data supplied by potential consumers, miscalculation of moves by competitors, temporary economic dislocations, etc. Inherently, there are fewer factors of control in estimates of market price than there are in estimates of production costs. Market analysis requires the very best in technical studies and seasoned business judgment. In the past, successful enterprises in industrial minerals have been carried out without exhaustive market studies, and perhaps this will continue. But if financial risks are to be minimized, the intensive market survey must be made.

Mesabi to the North

Already in fourth place in world iron ore production, Canada with 21.3 million tons in 1957 will soon receive a major boost from the 25 to 40 million ton production aimed for in Mt. Wright-Wabush Lake area.

FROM north to south activity is picking up throughout the Labrador Trough—already shown to be one of the world's great iron ore provinces. Center of current activity and interest lies in the mid-southern part of the trough as drills, equipment, and . . . money start to pour into the area near Mt. Wright and Wabush Lake.

First major announcement in the area came early this spring when J&L and CCI outlined an estimated billion-ton deposit for "future" operations. Later impetus came from rumored railway for US Steel's Quebec Cartier projects in the Mt. Reed area slightly to the south. As this issue went to press US Steel's request for bids on railway and hydroelectric construction, plus IOCC's decision to step up the timetable on its program in the Wabush Lake area east of Mt. Wright, triggered a flurry of other announcements involving many of the top U. S. and Canadian iron ore firms. Do not look for most of these place names in the average atlas . . . they aren't there yet, but they soon will be.

Singly none of the operations projected so far dwarfs IOCC's Knob Lake production, but collectively the new center near Mt. Wright bids to have an eventual output (if all plans go through) of 25 to 40 million tons of concentrates. Access to the new area hinges on either a spur connection to the east, joining the Quebec North Shore & Labrador Railway at about the 200-mile point on its way north to Knob Lake, or construction south to join Quebec Cartier's proposed railroad near Mt. Reed.

Quebec Cartier Moves Ahead

Quebec Cartier Mining Co. a wholly owned subsidiary of U. S. Steel Corp., is working on plans toward construction of a mill capable of producing 8 million tons a year of concentrates from about 20 million tons of crude iron ore. Quebec Cartier's interest lies with a group of deposits over a 70-mile zone from Mt. Wright to Mt. Reed. Preliminary plans are for a pilot plant at Lake Jeannine near the northern terminus of a 193-mile proposed railroad leading to a harbor at Shelter Bay. Part of project is a 175,000-hp power development harnessing the Hart Jaune River.

Mt. Wright and Wabush Lake Area

The largest property ever leased for iron ore reserves by Jones & Laughlin Steel Corp. sprawls over a 5640-acre plot in northern Quebec's Mt. Wright area. In this sparsely wooded land, under the muskeg of the Labrador Trough, about one billion tons of crude ore containing 335 million tons of concentrates have already been proved by diamond drilling. J&L, in partnership with Cleveland Cliffs Iron Co., holds a 99-year lease on the area—owned by Quebec Cobalt & Exploration Ltd. By agreement the lease is subject to cancellation on six month's notice.

The crude ore is nonmagnetic, some ten times coarser than the taconites—contains about 30 pct iron, and is much like the material mined and shipped from J&L's New York Ore Div. at Star Lake, N. Y. Upgrading should thus be less difficult and more economical than in taconite operations.

Although Jones & Laughlin has "no plans for the immediate development of the property" it notes that after beneficiation to 66 pct iron, the ore "will be used as a feed for J&L's blast furnaces at Pittsburgh and Aliquippa, Pa., and Cleveland."

In the adjoining area to the east Iron Ore Co. of Canada and Wabush Iron Mines (operated by Pickands Mather) are going ahead on other project. IOCC reportedly is committed to a mining venture rivaling its Knob Lake operation in tonnage. Construction of the spur from the QNS&LRy toward Wabush Lake is underway and its background of experience may put IOCC ahead in starting output of concentrates.

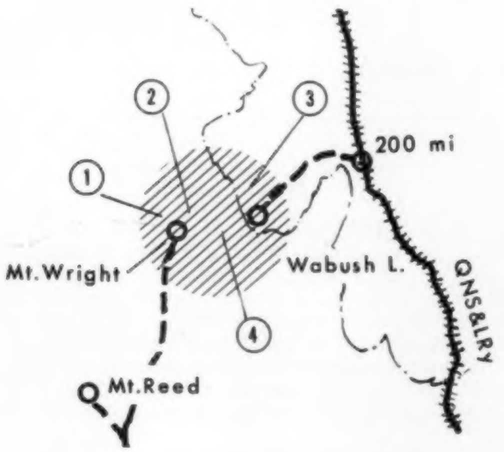
Other names cropping up in reports from the area include Canadian Javlin, involved in several properties in addition to Wabush Iron; Holannah; and Bellechasse whose holdings were optioned by W. S. Moore Co., Duluth, and re-optioned by Pickands Mather. Nearly a dozen other names are reported among those looking, exploring, or evaluating ore holdings.

Among factors favoring the deposits are their concentrating charactristics. Content of 30 to 38 pct Fe has been reported, and coarse liberation size, combined with apparently ready magnetic or electrostatic separation behavior has encouraged preliminary investigators. It is still to early to predict ore grades, concentration ratios, and impurity problems, if any, but laboratory tests have been favorable enough to cause large and experienced firms to aim for major financial commitments. Total plans for Quebec Cartier are expected to be of the order of \$200 to \$300 million; while the power project alone for Wabush Iron was quoted at \$25 million.

Far North and South

Near Ungava Bay, hundreds of miles farther north interest continues in the projects to open pit mine and to concentrate deposits there. Some weeks ago Oceanic Iron Ore was "continuing its investigations" but world conditions indicated that it will be "some time before any definite decision can be reached." In April, Alfried Krupp suggested the problems to be faced in the Ungava projects when he referred to ore shipment to Europe as "complicated" and pointed out that his own German plants could not absorb the whole tonnage envisioned. South, along the St. Lawrence, drilling is proceeding to give still further span to this iron ore province.

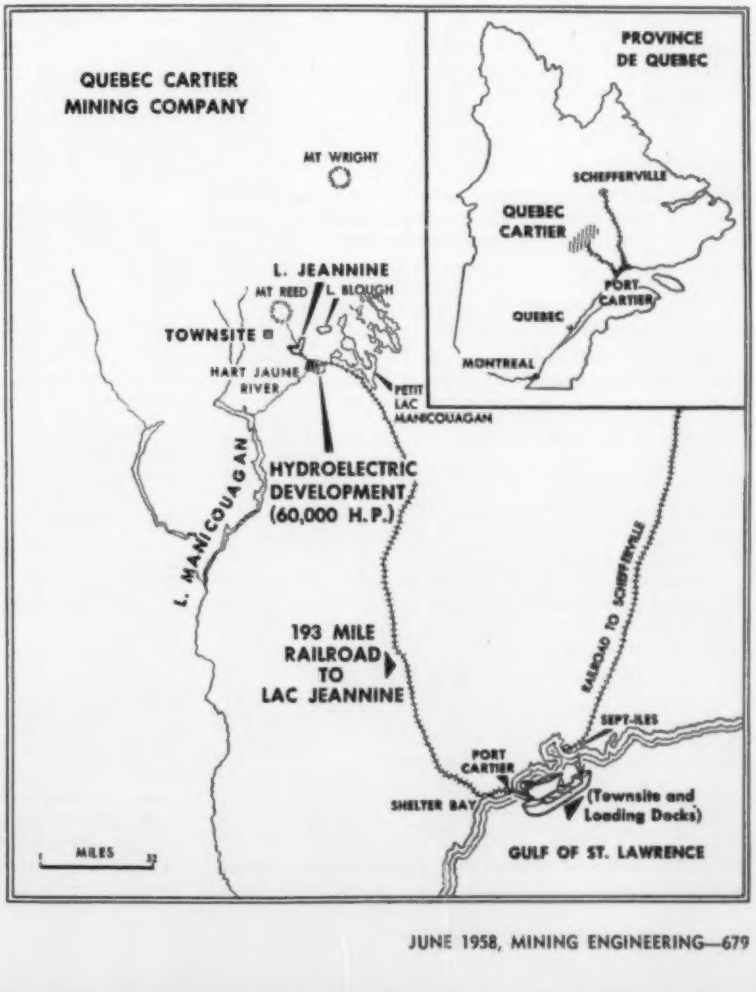
Mt. Wright—Wabush Lake Area



Center of current activity in this area lies west of QNS&LRy and north of the Quebec Cartier project shown in map below. 1. Quebec Cartier's Mt. Wright activity. 2. J&L-CCI undertaking announced earlier. 3. Labrador Mining & Exploration—IOCC steps up schedule for Wabush Lake. 4. Canadian Javlin, Wabush Iron Mining, Holannah, and Pickands Mather reported evaluating properties. Projected rail connections south and east are shown dashed.

Quebec Cartier

Hydroelectric development, railroad project, and site of preliminary plant are shown in map at right. Inset shows relationship to IOCC operations at Schefferville, Knob Lake area. Completion of the St. Lawrence Seaway will play major role in speeding iron ore projects and increasing impact on U. S. industry.



Canadian Iron Ore—

and where it will go in the next 25 years

Based on a paper by P. E. Cavanagh

SINCE the 1930's, the production of iron ore in Canada has increased from zero to about 15 million tons per year. In the same short period of about 25 years, the steel industry has doubled in output, while the consumption of steel has also doubled. In the 1930's all Canadian steel was made from imported iron ore, whereas today, Canada is exporting considerably more iron ore than she imports.

It appears certain that the production of iron ore in Canada will at least double in the near future, and should be over 45 million tons per year at the end of the next 25 years, in 1980. It also appears certain that most of this iron ore will be exported to the United States, with some proportion going to Europe. In this situation, it is logical and proper at the present time for Canadians to consider means of converting some of all of this Canadian iron ore into semi-finished or finished products in Canada.

Predicted Consumption of Canadian Iron Ore By the Canadian Steel Industry in 1980

	Population of Canada	Consumption of steel lb per Capita	Steel Consumption, tons
1955	15,000,000	800	6,000,000
1980	25,000,000	1,400	17,500,000

These are round number approximations and not intended to be very accurate since based on studies of such predictions in the past, they will probably turn out to be wrong and too conservative. The only excuse for such guessing is to arrive at a useful estimate of the importance of the various possible future markets for the Canadian iron mining industry.

Steel consumption per capita is only assumed to increase to the present level of consumption in the United States. This results in an estimate of an increase in steel consumption to about three times the present level. It is certain that some proportion of this total, in the form of special shapes and grades of steel, will still be imported. As a rough guess, let us say that about 15 million tons of steel will be produced in Canada to satisfy the market.

If this figure does not seem impressive to those outside of the steel business, it need only be said that the present production of England, France, or Germany is in this general neighborhood.

As an average figure, it takes one ton of iron ore to make one ton of steel by orthodox methods. This assumes that the ore is about 50 pct iron, so that it will make one-half ton of pig iron, to which can be added one-half ton of scrap steel to result in one tone of steel. Canadian steel companies have interests in iron mines in the U. S. and in 1980 will still probably import some iron ore from the United States.

We may therefore conclude that the Canadian steel industry in 1980 will use at least 12 million tons of Canadian ore, or approximately one-quarter of the ore produced there.

There is no foreseeable possibility by 1980 of consuming more than a small fraction of the output of Canadian iron ore by any entirely new methods of producing and marketing steel in Canada.

For a metallurgist, this leads to the conclusion that the development of increased use of Canadian iron ore in Canada is almost entirely out of his hands, since the major increase in use of Canadian iron ore in Canada will depend entirely on increasing the population, and in this field he can make only a minor contribution.

Estimated Markets for Canadian Iron Ore for 1980

The relative future importance of the Canadian markets for Canadian iron ore can be approximated as follows:

A. Export

Probable export sales 67 pct

Table I. Estimated Canadian Iron Ore for Export—1980

	Millions of Tons	
	Probable Minimum	Possible Maximum
In the Great Lakes		
from Lake Superior	5	10
from Lake Huron	2	3
from Lake Ontario	1	2
from Labrador via St. Lawrence R.	20	25
Total	28	40
In the Atlantic Ocean		
from Davis Strait	0	10
from Newfoundland	2	2
from Labrador via St. Lawrence R.	1	3
Total	3	15

P. E. CAVANAGH is Director, Dept. of Eng. and Met., Ontario Research Foundation.

Table II. Typical Reducibility Ratings of Iron Ores and Sinters by Russian Reducibility Test

Domnarvet (Sweden) Self-fluxing Sinter		44
Hofors (Sweden) Sinter		42
Magnitogorsk* (Russia) Self-fluxing Sinter —	1952	37
	1954	43
	1957	38-44
Steep Rock Ore		40
Steep Rock Sinter (Experimental Light Burned)		38
U. S. Hard Burned Sinter — Best Sample Tested		28
— Worst Sample Tested		20
Venezuelan Ore		38
Venezuelan Sinter		33

N. B. These tests were not run on properly selected representative samples, but on small *typical* samples. The purpose of the table is only to show the order of magnitude of the differences in reducibility ratings as obtained in this type of test.
* Russian data

B. In Canada

1. Expansion of the Canadian steel industry — 27 pct
2. Possible new processes for the Canadian market
   a. Electric smelting
   b. Sponge iron } 2 pct
3. Possible export market for melting stock — 4 pct

The United States will have difficulty in maintaining a production of 100 million tons per year of ore from its own deposits. About 60 million tons of imported iron ore will be needed to take care of the projected expansion of the American steel industry by 1980.

One-half to two-thirds of the ore imported into the United States will come from Canada.

Ore for Export in 1980

Practically all of the ore for export to the U. S. will pass through the Great Lakes and the tonnages generated at ports in Lake Superior, Lake Huron, and Lake Ontario are shown in Table I, as well as the ore entering the Great Lakes from Labrador by way of the St. Lawrence River.

It is presumed that practically all of the Canadian iron ore available in the Atlantic Ocean will go to Europe and that very little will reach the eastern coast of the United States to compete with Venezuelan ore.

It is estimated that less than half of the export tonnage will be the high-grade direct-shipping type such as Labrador and Steep Rock. Blended Labrador direct-shipping ores are higher in iron than the average of the ores now available and make excellent blast furnace feed. The plans at Steep Rock include up-grading of the as-mined ore to give a coarse high-grade $+\frac{1}{4}$ in. product with excellent characteristics, together with gravity concentration of the $-\frac{1}{4}$ in. fraction of the ore to produce a separate high-iron product. There are no other prospects at present for direct shipping Canadian ores which might be available in the Great Lakes for export in 1980.

The sinter available for export will include a continuing supply from Algoma. There is some possibility that a portion of the Steep Rock output will be in the form of sinter. The only other present prospect is that a large tonnage of U. S. Steel's Cartier and Mt. Wright deposits might be shipped as sinter. These deposits are relatively coarse-grained and after grinding and concentration would presumably be most suitable for production of sinter. There will be a small tonnage of by-product sinter produced by Noranda from by-product sulphide

Table III. Typical Analyses of Some Canadian Iron Ores, Pct

	Fe	S	P	Mn	SiO_2	Moisture
Wabana	50.93		0.80		12.8	1.61
Quebec IOCC (Bessemer)	56.73		0.030	0.040	5.4	8.8
(Non-Bessemer)	52.2		0.06	1.24	7.28	10.5
Bethelehem-Marmora Pellets	66.4					
INCO Pellets*	68	0.01	0.003	0.05	1.5	0
Noranda Sinter	68	0.05			2.5	
Algoma Sinter	50.75	0.095	0.022	2.87	11	0.75
Steep Rock	53.3	0.029	0.027	0.2	6.5	9.5

From "Survey of Iron Ore Industry in Canada", T. H. Janes, Dept. of Mines, Ottawa, MR22.
* Ni = 0.15 pct

in plants at Blind River on Lake Huron and Port Colborne on Lake Erie.

Most of the other Canadian deposits are low-grade magnetite or hematite, or mixtures of magnetite and hematite which require relatively fine grinding to produce a satisfactory concentrate. At present pelletizing is the preferred method of agglomeration for the finer grinds so that the estimates contain a considerable tonnage of probable pellet production. In addition to the present pelletizing plants of Bethlehem Steel at Marmora, and of Steel Co. of Canada and Pickands-Mather at Hilton Mines, the estimate includes somewhere between 5 and 10 million tons additional in the form of pellets in the Great Lakes, originating in Ontario and Quebec. The continuing production of iron by-product pellets at International Nickel will contribute to this total.

The ore available on the Atlantic Ocean, a major portion of which is assumed to go to Europe, will be composed of the expanded production from Wabana of a gravity-concentrated product and probably some small portion of sinter or pellets from Labrador and Quebec. The economics of production from Ungava and Hudson Bay have not been fully explored. Fine-grained concentrates available would have to be produced in considerable tonnages, if at all, in order to establish a profitable operation. The fine-grained ores require fine grinding so the concentrate would probably be pelletized.

Characteristics of Canadian Iron Ores

While it is now widely recognized that high reducibility is a very valuable characteristic of iron ore or agglomerate, it is a fact that high reducibility is obtained at a sacrifice in shipping strength. This means in turn that very high reducibility sinter or pellets would normally be made only at the blast furnace site. (It is stated that a difference of 2—from 40 to 38—in the Russian reducibility rating results in a loss in production of about 5 pct for a blast furnace which is taking full advantage of the high reducibility represented by a rating of 40.)

Since Canadian sinter and pellets will have to be shipped for long distances, it is obvious that they will have to be hard burned to withstand shipping. It is therefore important to recognize that excessive shipping strength is gained at the expense of blast furnace production and to be able to evaluate agglomerates in particular so that blast furnace production is not sacrificed for needlessly high shipping strength.

Reducibility tests have been in use for many years. The apparatus used at the Ontario Research Foundation is shown in the figure. For use in routine testing, we believe the Russian reducibility method would be preferable for rating iron ore agglomerates and iron ores as blast furnace burden material.

The Russians have collected a great deal of data on the performance of blast furnaces as correlated with their type of reducibility test and it is believed that such correlation with practice would be of value in North America. Some approximate ratings on some Canadian ores and agglomerates and based on the Russian method are presented in Table II. Characteristics of Canadian ores are shown in Table III.

In spite of the necessary high strength for shipping purposes (that must be obtained at the expense of reducibility), Canadian agglomerates in the form of sinter and pellets will also be premium blast furnace raw materials presumably with less silica than taconite pellets. The main objective will be to maintain as high reducibility as possible in these materials without sacrificing shipping strength.

Iron Ore Reducibility Tests

North American Method—As shown in the figure, which illustrates the apparatus used by Ontario Research Foundation, the weighed sample of standard screen analysis is placed in a capsule of standard design so that gas contact time is known and controlled. The chosen gas, usually pure hydrogen, but carbon monoxide or a mixture of these two gases if desired, is introduced at the bottom of the capsule at a standard flow rate of 0.5 cfm for a 500g sample. The gas rises through the bed or ore and is burned on leaving the metal capsule. The loss in weight is recorded either continuously or at regular intervals until the oxygen is all removed and a constant weight for the remaining metallic iron is obtained. Reducibility ratings may be calculated according to the method of Philbrook[1] or by taking the time required to achieve 90 pct removal of oxygen.[2] Usual test temperatures are 900°C or 1000°C.

Russian Reducibility Tests—The apparatus is the same as for the North American method with minor variations in design of equipment. Sample weight is 400 g, but the test temperature is 700°C and the reducing gas used is bosh gas or a standard analysis of mixed bottled gas close to the analysis of blast furnace gas. The test is run for only 30 min. The reducibility rating is the percentage of the total oxygen loss which is achieved in 30 min under these conditions. A rating of 40 indicates that 40 pct of the oxygen in the iron oxides has been lost.

Suggested Reducibility Tests for Production Use—A sample of 1000 or 2000 g of specified screen analysis is heated in a standard container in which the contact time with reducing gas is the same as in the above laboratory types of test. The sample is brought up to test temperature in an equivalent flow of nitrogen and weighed when constant weight has been reached. Flow of reducing gas at 0.5 cu ft per lb sample is then maintained for 30 min the loss in weight recorded. It is suggested that the reducing gas might be bottled carbon monoxide.

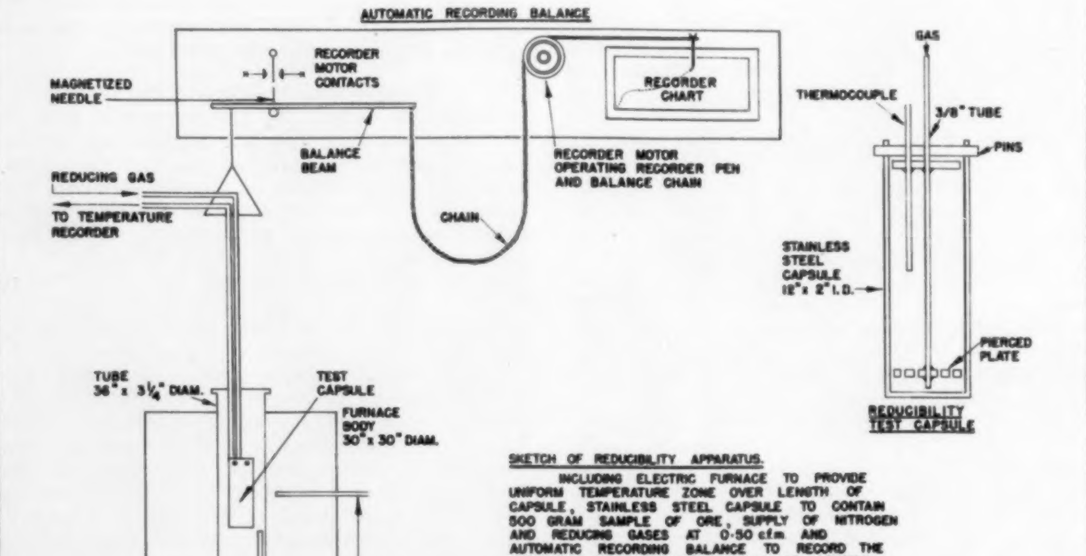
References

[1] W. O. Philbrook—Reducibility of Sinter, Blast Furnace & Steel Plant, August 1943.

[2] Barrett & Wood—Loss in Weight Method of Determining Ratio of Deoxidation of Iron Oxides, Ind. Eng. Chem. Anal., Vol. 18, May 1946, p. 285.

Barrett & Wood—Relative Reducibility of Some Iron Oxide Materials, U.S. Bureau of Mines, RI 4569, October 1949.

[3] L. A. Roe—Iron Ore Beneficiation 1957, Minerals Publishing Co., p. 177.



SKETCH OF REDUCIBILITY APPARATUS.

INCLUDING ELECTRIC FURNACE TO PROVIDE UNIFORM TEMPERATURE ZONE OVER LENGTH OF CAPSULE, STAINLESS STEEL CAPSULE TO CONTAIN 500 GRAM SAMPLE OF ORE, SUPPLY OF NITROGEN AND REDUCING GASES AT 0·50 cfm AND AUTOMATIC RECORDING BALANCE TO RECORD THE LOSS IN WEIGHT OF THE SAMPLE AS HEATING AND REDUCTION PROCEED.

FIGURE 1.

Flash Smelting Copper Concentrates

Condensed from a paper

by Petri Bryk, John Ryselin, Jorma Honkasalo and Rolf Malmstrom

THE theoretical possibilities for the realization of flash smelting have been known for a long time. Calculations concerning the same can be found in previously published literature,[1] and suggestions for its accomplishment in practice are described in patents on the subject. Likewise a smaller number of practical test results are known.

Autogenous smelting is closely connected with flash smelting, since in flash smelting techniques it is possible to use the heat evolved by oxidation of the sulfides for the smelting process to such an extent that under certain conditions smelting can proceed without additional fuel. However, in the event that insufficient heat is available from the oxidation of the sulfide concentrates, then additional heat may be supplied by preheating the air, using oxygen enriched air, on burning additional fuel with the concentrate.

PETRI BRYK, JOHN RYSELIN, JORMA HONKASALO, and ROLF MALMSTROM, are associated with Outokumpu Oy, Finland. Paper presented at AIME Annual Meeting, New York, February 1958.

The first flash smelting method which has been realized on a commercial scale is the **Outokumpu process.**[2] It has been operated on a commercial scale at Harjavalta, Finland, since 1949. The Ashio Smelter of the Furukawa Mining Co., which went into operation in 1956, has also adopted the Outokumpu system.

In this process oxidation reactions are carried out in a vertical shaft, in a downwardly flowing concurrent system. Preheated air and dried concentrate in proper proportions are fed into a burner on the top of the reaction shaft. The mixing of air and concentrate takes place effectively in the burner, and the resulting suspension is directed vertically downwards into the shaft in such a manner that it is spread over the whole shaft area. When the particles enter the hot shaft under these conditions, ignition takes place instantaneously. By exothermic reactions the temperature of the particles is raised to the smelting temperature. At the same time, the partial pressure of oxygen decreases, so that by leaving the reaction shaft it will be close to zero. In this way, a good utilization of oxygen is achieved,

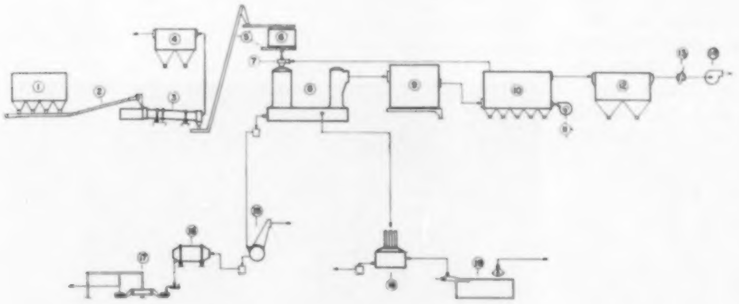


Fig. 1—Flowsheet of the Harjavalta smelter: 1, concentrate storage; 2, belt conveyor; 3, dryer; 4, dryer cottrell; 5, Redlers; 6, feed hopper; 7, concentrate burner; 8, flash smelting furnace; 9, waste heat radiation boiler; 10, heat exchanger; 11, primary air fan; 12, cottrell; 13, damper for automatic draft control; 14, gas fans; 15, converter; 16, anode furnace; 17, casting wheel; 18, slag cleaning furnace; and 19, slag granulating.

Fig. 2—Harjavalta flash smelting furnace and waste heat boiler: 1, concentrate burner; 2, reaction shaft; 3, settler; 4, uptake; 5, radiation waste heat boiler; and 6, traveling grate. The reaction shaft is a 26-ft high, 12 ft ID cylinder lined with chrome-magnesite brick. There are two water-cooled rings in the lower part of the shaft.

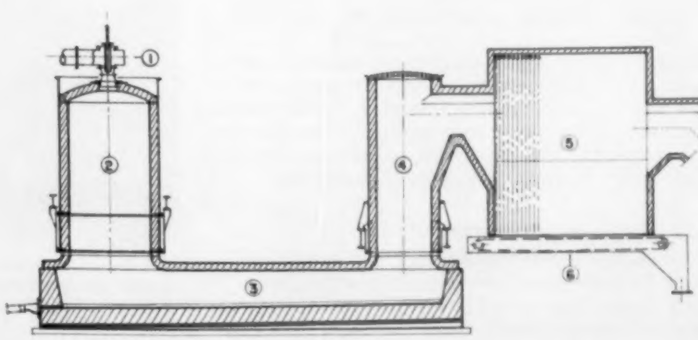


Table I. Operating Statistics for the Harjavalta Smelter, October 1957

Typical Analyses, Pct	Cu	Fe	S	SiO_2	Ni	Co	Zn	CaO
Concentrates	20.7	31.8	33.2	4.8	0.18	0.13	3.22	
Flux				80				
Matte	61.6	12.0	22.3		0.33	0.12	1.5	
Slag (Dump)	0.53	38.0	1.2	29.7	0.09	0.21	4.7	1.2

Flash Smelting Furnace Operation	
Concentrate smelted, metric tons	14,492
Flue dust (obtained and re-fed), metric tons	878
Oil in flash smelting furnace kg per metric ton concentrate	14.2
Oil in concentrate dryer kg per metric ton concentrate	6.3
Steam generated kg per metric ton concentrate	380
Air preheating temperature, °C	510

provided that the dimensions of the reaction shaft are correct.

Separation of the particles from the gas takes place when the gases are turned through an angle of 90°, upon leaving the reaction shaft. Gases containing mostly sulfur dioxide and nitrogen are exhausted from the furnace at a temperature slightly above the slag temperature.

The particles are collected in the molten bath in the settler, which is located horizontally below the reaction shaft. Iron oxide and silica from the feed react, forming slag and at the same time, molten matte drops are separated and collected on the furnace hearth. The matte grade is easily controlled by the ratio of air to concentrate. By altering the air preheat temperature, the temperature in the furnace can be kept on a desired level. If the concentrate to be smelted has a composition which requires air preheat temperatures too high to be reached practically, the remaining heat can be provided by burning extraneous fuel, together with the concentrate, in the reaction shaft.

Another flash smelting system which is now in operation on a commercial scale, is the International Nickel Co.'s process.[10] Instead of preheated air, the INCO process uses almost pure oxygen to eliminate the heat deficit in the system. The combustion of sulfide concentrate is carried out in a similar manner, as suggested by Klepinger, i.e. in a horizontal flow. Obviously, the rich oxygen atmosphere accomplishes such a reaction velocity that the desired oxidation of sulfide particles can be obtained before the particles reach the molten bath. This INCO process has been in operation at Copper Cliff since 1952.

The Furukawa Mining Co. in Japan decided in 1954 to modernize their copper smelter in Ashio. After a thorough study of the Outokumpu flash smelting process in Harjavalta, they considered it to be the best solution in their case and resolved to adopt the system.

The new smelter which started up in March 1956, operates on the same general principles as the Harjavalta smelter, although the choice of the auxiliary equipment is different in some cases. The operations at Ashio smelter are described by Okazoe of the Furukawa Co. in an article recently published.[12]

Summary

The standard pyrometallurgical process for copper usually comprises three stages: roasting, smelting, and converting, which are generally carried out in different metallurgical units. Roasting and converting are both markedly exothermic processes, whereas smelting is the heat consuming part of the process. In standard practice a large amount of the heat of the exothermic processes is lost, whereas flash smelting is characterized by the idea that two of the three processes are carried out simultaneously in one unit, the flash smelting furnace. This leads to a considerable saving of fuel and, depending on the composition of the concentrates, the smelting can even be carried out autogenously.

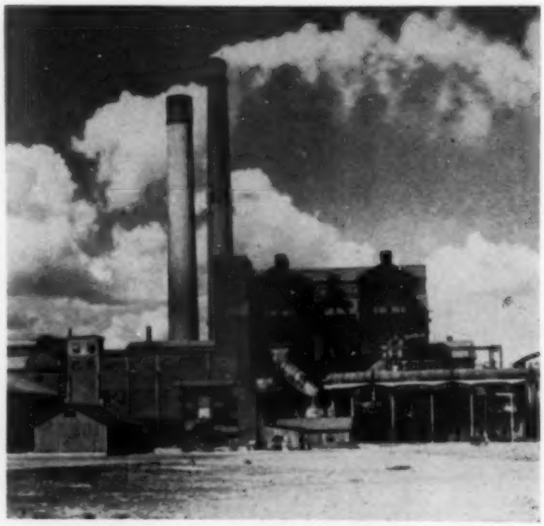
In reverberatory smelting the heat content of the waste gases is normally recovered, but the sulfur eliminated in the furnace normally cannot be recovered economically because of the excessive dilution of the gas. Contrary to this, the flash smelting furnace gases are, after passing the waste heat boiler, an ideal feed for the sulfuric acid plant because of the steady flow and unusually high sulfur dioxide content. As there are practically no sulfur losses, except in the slag, sulfur recovery is very high.

Experience has also shown that the refractory lining in the flash furnace, especially the roof, has a much longer life than in a reverberatory furnace. A considerable saving is also effected in the converter operation, because flash smelting normally produces a high-grade matte whereby the converters require less compressed air, and the slag blowing stage is shortened. For this reason the converter lining can also operate under less strenuous conditions.

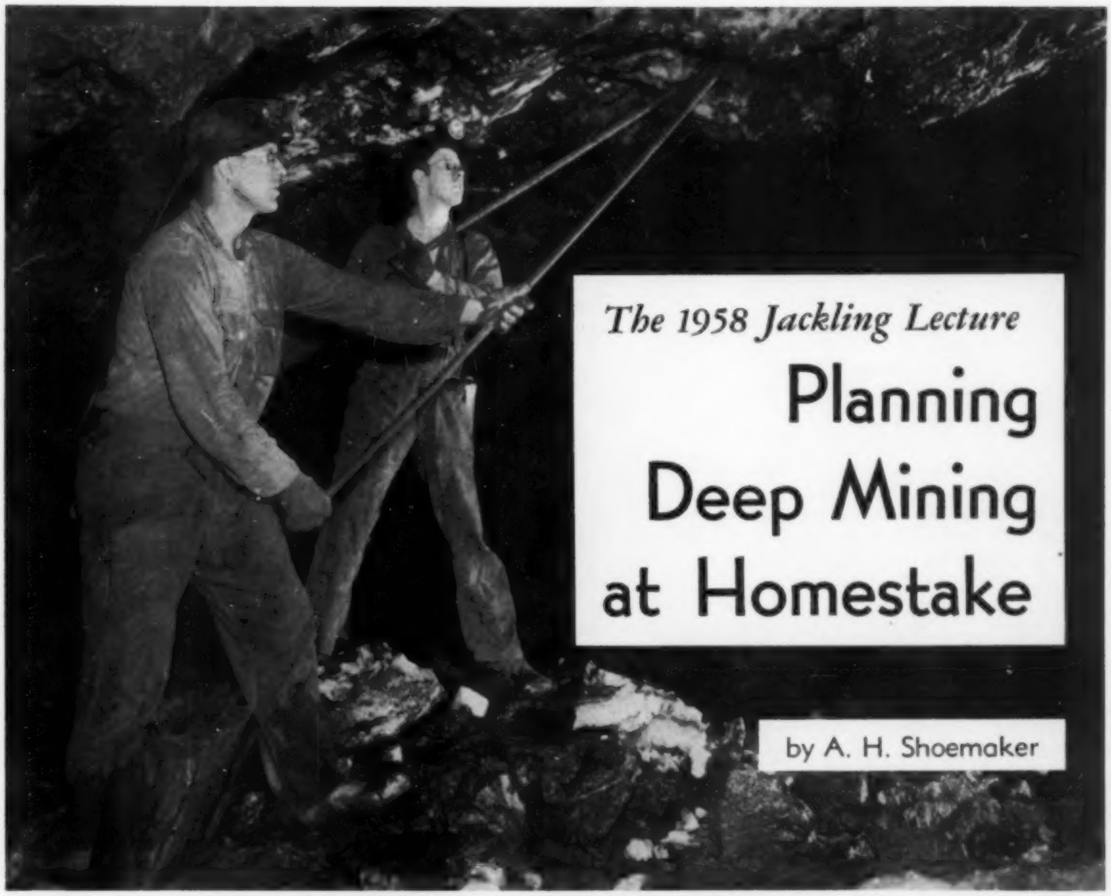
Arthur G. McKee & Co. is licensed by Outokumpu to engineer smelters using their process in the Western Hemisphere.

References

[1] T. E. Norman: *Engineering and Mining Journal*, 1936, vol. 137, p. 499 and p. 562.
[2] Klepinger, et al.: U. S. Pat. No. 1,164,653.
[3] Krejci: U. S. Pat. No. 1,915,540.
[4] Freeman: U. S. Pat. No. 1,888,164.
[5] Leiserovitch, et al.: *Zvetny Metally*, 1936, no. 10, p. 1936.
[6] Tonkonogi, et al.: *Zvetny Metally*, 1957, no. 1, p. 30.
[7] Shulzinger: *Zvetny Metally*, 1957, no. 1, p. 42.
[8] A. Lange: *Metallurgie und Giessereitechnik*, 1954, no. 12, p. 538.
[9] P. B. Bryk, et al.: U. S. Pat. No. 2,506,557.
[10] JOURNAL OF METALS, 1954, vol. 6, p. 416.
[11] F. Benitez: *Engineering and Mining Journal*, 1953, vol. 154, no. 10, p. 76.
[12] T. Okazoe: *Journal of the Mining Institute of Japan*, 1956, vol. 72, no. 822, p. 691.



The Harjavalta Smelter at Outokumpu Oy, Finland. In 1944 the smelter was moved from eastern Finland and erected in 7 months. Center buildings house waste heat boilers which were built in 1949.



The 1958 Jackling Lecture

Planning Deep Mining at Homestake

by A. H. Shoemaker

THE shutdown of Homestake by Government order L-208, with its consequent disruption of a very stable and trained working force, coupled with postwar inflation and the coincidence that a mining depth had been reached that posed problems of ventilation, access to exploration areas, and choice of mining methods that would be applicable to zones of greater rock pressures made a very searching analysis of every phase of Homestake's operations a necessity.

Any changes to be made had not only to meet the problems of deeper mining but also had to provide greater efficiency so that the mine might operate at a substantial profit until such time as a gold price adjustment might be forthcoming that would offset post-1945 inflation.

Geology and Mining Situation

The Homestake mine lies in the northern Black Hills in an area of Pre-Cambrian rocks exposed by the erosion of the paleozoic formations which covered the Black Hills.

The Pre-Cambrian rocks in the vicinity of Lead comprise metamorphosed sediments with a total thickness of about 20,000 ft. The oldest formation, the Poorman, is ankeritic carbonate schist. The next oldest, the Homestake formation, host rock for all Homestake orebodies, is a siliceous iron-magnesium carbonate schist. The younger formations are dominantly argillaceous with some quartzites. Tertiary intrusive rocks cut all formations.

The Pre-Cambrian rocks have undergone extreme isoclinal folding. Superimposed on this intricate folding are zones of shear folding which cross the isoclinal folds at small angles.

The Homestake orebodies are pipelike replacements of the Pre-Cambrian Homestake formation where certain cross folds intersect some earlier isoclinal folds. These orebodies plunge flatly to the southeast at variable angles locally as steep as 45°.

The orebodies are replacement areas where numerous vein quartz of irregular shape have formed with surrounding zones of chlorite alterations containing disseminated sulfides and metallic gold. Where the numerous individual quartz veins with the sulfide and gold-bearing alteration zones are close together, large irregular orebodies with a roughly elliptical plan outline result. These ore zones may be more than 200 ft wide and 700 ft long in plan area. They have followed down the plunge of certain severely folded structures with great persistence.

Two vertical operating shafts, the Ross and Yates, serve the mine, one with rope capacity to reach the 4850 level, the other to the 5000 level.

A. H. SHOEMAKER, Member AIME, is Vice President and General Manager, Homestake Mining Co., San Francisco.

TP 4747A. Manuscript, Jan. 17, 1958. New York Meeting, February 1958.

The Transactions papers appearing in MINING ENGINEERING during 1958 will subsequently appear in AIME Transactions Volume 211, and may be permanently referenced to that volume.

The Daniel C. Jackling Lecture

An annual invitation address by an outstanding man in mining, geology, or geophysics who has contributed significantly to the progress of technology in these fields.

The Citation for the Award:

For leadership in efficient mine operation, resulting in profits under a fixed gold price in spite of inflationary costs, and for his Lecture, "Planning for Deep Mining at Homestake."

The Award Committee:

Clark L. Wilson, Chairman

R. V. Pierce — E. A. Jones

H. V. W. Donohoo — D. M. Fraser

The combined hoisting capacity of these two shafts from lower levels is in the order of 6000 tpd. The Ross shaft lies to the west of known ore zones, the Yates to the east. The horizontal distance via the drives from these shafts to the point where Homestake ore plunged below the 5000 level is about 6400 ft.

Ventilation to the 4100 level was entirely adequate for the mine above that level, but insufficient to do more than furnish enough air for the initial development to the 5000 level. Homestake was faced, therefore, not only with the problem of providing ventilation for deepening the mine, but with furnishing adequate additional air for a substantial percentage of the developed ore reserves. The mining system, which will be described very briefly below, left sufficient ore tied up in pillars in the upper levels so that the present volumes of air serving upper levels could not be diverted to lower levels for many years.

Shrinkage stopes 60 ft in width in the direction of the plunge, with intervening pillars 40 ft wide mined by panel square setting, furnished the entire production.

In the 1930's Homestake had developed an underground distribution system for hydraulic fill. The sand fraction of the sand-slime split only was used for fill. An effective method of fill for any mining system was therefore already in operation.

New Development Shaft

Since both the Ross and Yates shafts had reached their ultimate depth, there was no other available method of getting below the developed bottom of the mine than to sink an interior shaft. Positioning the new shaft near either the Ross or Yates would have required excessively long drives to reach the ore areas, and would have eliminated the use of one of the shafts for the hoisting of transferred ore. Therefore the site of the new interior shaft was chosen some 6400 ft south of the Yates shaft, near the point where the Homestake formation plunged below the 4850 level.

The possibility that the interior shaft sinking could be postponed until a drilling campaign could give assurance of sufficient reserves to justify the larger expenditure of this deep level program was studied.

Because of the low angle plunge of the orebodies, such a drilling program would have required a very extensive development pattern on the lowest level. These drifts and crosscuts would have served no other purpose than access to chosen drilling sites.

Past experience had shown that only flat holes at right angles to the planes of schistosity had any chance of reaching a predetermined target. Because every hole ultimately became normal to the dip of the schists there was no chance of reaching more than 300 ft vertically below the collar elevation of any hole. Steep holes had been tried on several occasions and had been very carefully surveyed. Their courses were so erratic that any thought of getting reliable information from steep holes had to be abandoned.

Furthermore, these structures cannot be projected with precise accuracy even one level interval, let alone hundreds of feet. Therefore nothing less than a close interval drilling pattern over very large areas would give reliable information on ore occurrence. The cost of such a program would be excessive.

This left no choice but the early sinking of the interior shaft. Its size was chosen to allow a minimum 3000-tpd capacity. Its caging capacity was sufficient to permit initial development on several levels without installation of an ore hoist. Choice of size of the ore hoist could then be deferred until significant ore reserve information was available.

Equipment Development

Since a major transfer level was a necessity, the question naturally arose as to whether or not a change in size of equipment, track gage, and drifts would be feasible. Because Homestake was a very old mine the track gage was 18 in. and locomotives and cars were small.

Practically all of the development openings from the 5000 level up were 7 x 7 ft. Crosscut turnouts were on 20-ft radius curves. A very cursory glance at the problem of revamping the active part of the mine for a wider gage showed its impracticability.

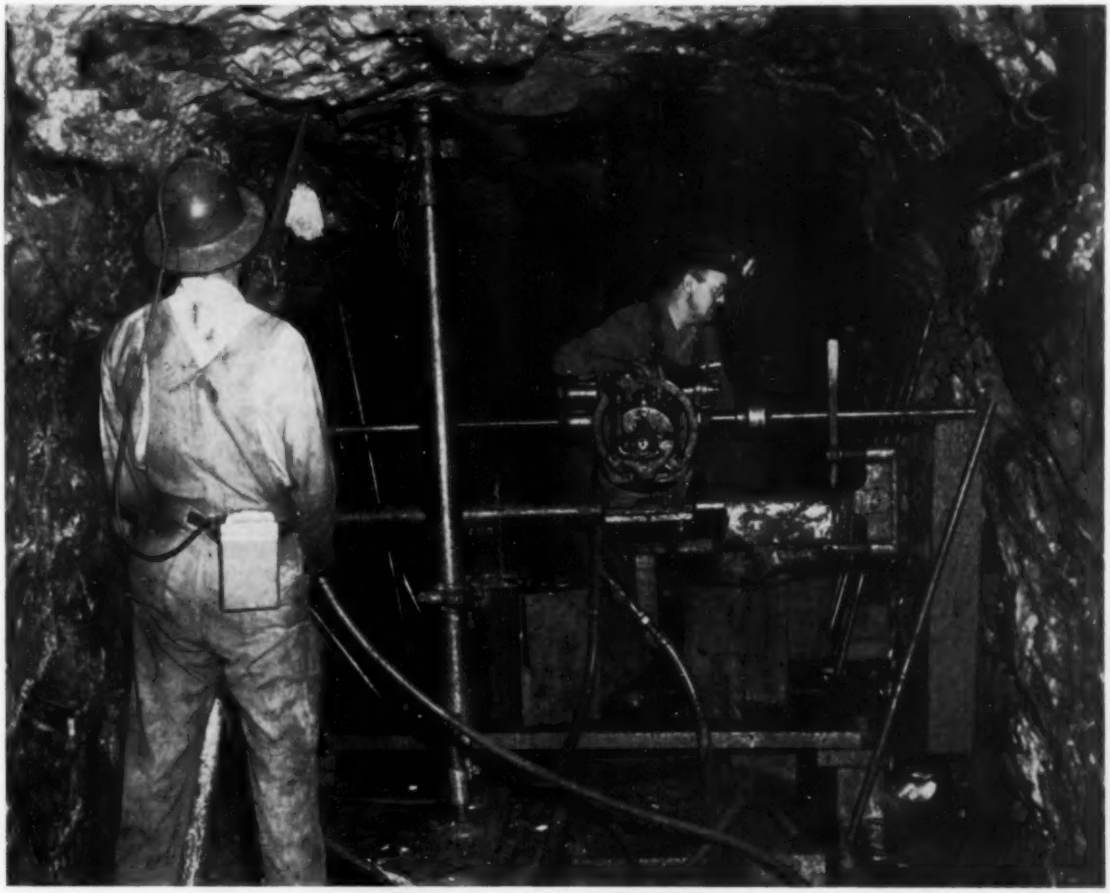
The use of broader-gage larger equipment would then have been limited to the 5000 level and below. Since no reserves were proven below the 5000, this high initial re-equipment cost would have had to be borne without any assurance of its repayment.

A very effective 60-cu ft Granby car to replace the old 20-cu ft cars had been placed in service prior to the war. Battery locomotive manufacturers came up with an 18-in. gage locomotive capable of delivering 1000 tpd from stoping areas to shaft pockets on the longest haul level and still able to negotiate Homestake's short-radius curves. Scheduling of ore production showed that such a capacity was adequate for any foreseeable mining rate.

The small mucking machines in use were inadequate and the proper size was dangerously unstable on an 18-in. gage track. This problem was solved by building outriggers on the larger mucker, preventing any overturn.

Since adequate haulage capacity could clearly be demonstrated without gage change, the thought of a differently equipped lower mine section was given up.

By 1952 stoping had progressed downward to the point where a considerable tonnage had to be mined below the 3650 level. One of the first large shrinkage stopes driven from the 3800 to the 3650



Diamond drill station at Homestake.

level gave quite definite evidence that rock pressures were sufficient to make continuation of shrinkage stoping below the 3650 unwise, for within a period of several weeks the back began to spall wherever it was convex downward.

Panel square setting, the method used to extract the pillars between shrinks, was a high cost system, particularly since the introduction of hydraulic fill, which required the preparation of each panel on every side to hold the fill by the use of S4S 3 x 12-in. tongue and groove lumber. Also the increasing weight on the pillars made sizable rock falls more probable. Since no fill could be introduced until the completion of a panel 75 ft high, the danger of losing an entire panel was increasing.

Coupled with the physical conditions described above was the fact that the outline of the orebodies in the deeper levels was much more irregular than in the upper levels. This greater irregularity was causing difficulty in recovering ore from shrinkage stopes. It was necessary at times to set up slushers in the shrinks as they were being pulled to remove ore from flat benches.

Because most shrinks were bottomed between levels, numerous drawpoints were economically impossible. This situation resulted in large conical holes in the muck pile when *relief* was drawn, thus severely limiting the back areas that could be drilled at one time. This forced a miner to drill a pattern of diverging holes from any one possible set-up. The result upon blasting was a great deal of oversize rock, which had to be blockholed. Also some of the oversize which landed near the bottom of the draw cone could not be drilled, creating a difficult chute drawing and blasting problem.

The indirect costs—such as wear on cars and skips, adverse effect on dust concentration caused by excessive chute blasting, the occasional tonnage of unrecovered ore when bad back or wall conditions made full clean-up impossible—led to the belief that there was an appreciable margin in favor of some other system not revealed by direct cost comparisons.

Need for New Stoping Method

Changing mining methods in a mine that had developed a standardized procedure with which miners were thoroughly familiar was a serious step. However, for the lower level ore reserves, there was no choice. The only area of choice was in whether or not one selected change for deeper level ore could be applied to all ore with an increase in efficiency over the old procedures.

No method could be given serious consideration if any appreciable grade reduction would result. Any sublevel caving system was inapplicable because of the extremely irregular ore outlines, coupled with the toughness of the rock and its characteristic of breaking in large sizes. Also because of labor shortage any method requiring large advance stope development ahead of production would have curtailed output.

Open cut and fill stoping seemed to meet Homestake's requirements better than any other method studied. By this method a more effective grade control is possible than with any other, not excepting square setting. Irregular ore can be followed, no matter where it leads. Any sizable waste areas within the outside ore limits can be left unbroken in the stope. The completed cut can be quickly sampled with jackleg drills and thus any variations of ore distribution in the succeeding cut can be known in advance and properly planned for.

One of the most serious problems of shrinkage stoping at Homestake, that of dilution from infolded waste pendants near the top of the stoping section, can be handled readily by dividing the section in two parts. As soon as the cut is sand-filled the waste is then firmly supported, thus safely securing the waste inclusion. Such an occurrence in a shrinkage stope was always a worrisome hazard.

The amount of stope preparation work could be reduced materially, as cut and fill sections longer than 150 ft can be easily handled. The former method required two crosscuts each 100 ft. Raising was proportionately reduced.

There is a distinct disadvantage in that this development pattern gives less reliable grade information from initial development. Thus far there has been no difficulty in determining whether or not a block is or is not of commercial grade, but the production grade will not check the estimated grade with the former accuracy. On occasion it is very probable that additional development, not required for extraction, will be necessary to determine the feasibility of mining certain areas.

Any system which Homestake hoped to apply to the deep levels with their increasing rock pressures and eventual appearance of rock burst conditions had to eliminate pillars, as the reduction of a block of ground in the rock burst zone to remnant pillars is inviting violent failure with the consequent loss of ore and, in addition, a hazard to mine personnel. It also had to permit a reduction in the size of the stope opening whenever experience might dictate the necessity of smaller ones.

Conversion to New System

As the conversion to cut and fill progressed it became necessary to limit the length of stoping section. When this is done a single timber deadline is built to retain the sand fill when the adjacent panel is mined later. Scrap timber and outside log cuts are used for this purpose. Thus far when the next stoping section is kept 20 ft vertically below the upper section, there has been no spill-through when the upper cut is being filled.

Since gravity could no longer be used for ore removal, the ore had either to be slushed or handled with trackless equipment. Because of the difficulty of getting trackless equipment into the stopes, the necessity of repair and maintenance *in situ* unless dismantled, the great difficulty of storing while filling, and the high cost of each unit compared to slushers, slushing was chosen as the means of removal.

The size of slushers chosen is a compromise between optimum size and easy mobility. The manufacturers have been very helpful in that they have designed higher-horsepower motors for application to the smaller hoist frames. Homestake has, then, an adequate unit light enough for stope crews to move it without special rigging, saving the lost time and extra expense of a special bull gang.

Homestake's department has designed a control unit mounted in one weatherproof case, which is installed out of the stope near the manway raise. The only control in the stope is a stop-and-start pushbutton switch. The power cable running from control box to the slusher in the stope is long enough to permit moving the hoist to any desired position in the stope without relocating the control panel. By this set-up electrical work can be limited strictly to authorized electricians.

Securing the slusher hoist proved difficult in sand-filled open stopes. The mine department came up with the answer—screw bits into the sand fastened to the frame.

By use of jacklegs a closer, uniform spacing of holes was possible with a consequent marked improvement in fragmentation. Also the chute openings in the stopes were grizzlied, causing a marked decrease in chute blasting.

Conversion of an uncompleted shrinkage stope to cut and fill was an easy procedure. As soon as a shrink reached the level it could be drawn empty, and sand-filled, and cut and fill stoping started above the level. Also the intervening pillar could then be included in the cut and fill section, eliminating high-cost timber stoping.

One of the important advantages of shrinkage stoping was lost by this conversion, namely, the maintenance of a large broken ore reserve which made uniform production possible during periods of labor shortage. Compared to shrinkage, cut and fill increased timber consumption for flooring by one board foot per ton.

To make up for this broken reserve cushion an additional ball mill was installed, together with extra vat capacity so that higher tonnages could be handled in the winter to compensate for summer labor shortages. Fortunately since 1953 Homestake's labor force has been quite stable; it has been possible, therefore, to increase overall production rather than merely compensate for times of labor shortage.

Panel square setting was abandoned as soon as stopes could be filled and timbered cut and fill stoping substituted. Only one working floor is kept open. This permits securing the back as the stope is timbered, eliminating many spills and greatly simplifying repairs when they occur, as damage to timber is limited to one floor. The size of timber was successfully reduced from 12 x 12 in. to 10 x 10 in., with an important cost saving. Also, by this method it was necessary only to lace around chute and manway to contain the sand fill.

At the start of these changes certain key contract crews were chosen to demonstrate their effectiveness. To minimize *heel dragging* the crews were guaranteed previous earnings. Contract earnings early in the game increased materially and no serious resistance from contract crews ever developed. Without such preliminary guarantees it is very doubtful that such a painless conversion would have been possible.

The geothermal gradient at Homestake is high, particularly so for rocks of great geological age. The range is from a low of 44°F on the 300 level, which is the mean annual temperature, to 103.1°F on the 5600—an average of 1.1° per 100-ft increase in depth. This is not a straight line curve. From the 2300 to the 3500 level the average is only 0.77°F per

100 ft. From the 3500 to the 4850 the increase is 1.6°F per 100 ft. From the 4850 to the 5600 the curve flattens again to 1.2°F per 100 ft. Projecting the average increase from 3500 to 5600, rock temperatures in excess of 130°F are anticipated for the 7500 level. It is of interest that in the ore zone rock temperatures are encountered that are several degrees higher than in waste rock.

It is extremely difficult to predict at what vertical depth the economic limit of mining will be reached. The tenor of the ore to be found in depth, ground behavior, actual rock temperatures as contrasted to those predicted, coupled with the unknowns of labor and supply costs and price of product in years hence, make only a guess possible. Yet some guess had to be made, for the production limits imposed by the choice of ventilation capacities made at this time probably would be controlling, regardless of the outcome of development at the bottom limit imposed by the choice.

The decision was that this lower work should be capable of being extended to the 7500 level, and that adequate volumes of air should be provided to stope simultaneously on three levels and do preliminary work on two others. Probable stoping layouts on a typical level were made and the requirements of that layout were multiplied by the factors given above. The capacity to be provided as determined by this estimating came to 350,000 cfm.

Since the distance to the nearest part of the new area to be developed was a mile and a quarter, the furnishing of this additional ventilation capacity from existing openings required transferring that distance through a drift with rock temperatures approaching 100°F. Humidity would have approached saturation. The existing openings were too small to accommodate the required volumes. Increasing velocities to deliver an adequate volume would have made working conditions intolerable and would have increased power consumption fantastically.

It was obvious that the proper solution was a new vertical shaft connecting directly to the 4850 level close to the collar of the interior shaft. Air at approximately the humidity of the surface air could then be delivered to the 4850 and only the lower 1300 ft of the shaft would be in the rock temperature zone of plus 80°F. Under such conditions the introduction of cooling could be deferred several years.

Should orebodies persist several thousand feet below the developed part of the mine, it is a certainty that cooling will eventually be necessary. That possibility was taken into account in the plans for the new ventilation shaft. Ample water is available and the Lead area has sufficiently low humidities to make a closed high pressure loop with surface evaporative cooling practical.

An 18-ft diam circular shaft with a permanent hoist, manway, and pipe compartment on one side met the requirements noted above. During sinking of the shaft the necessary stations will be cut to provide expansion loops in the high pressure system when installed.

This plan called for the introduction of some 350,000 cfm, for which exhaust capacity had to be provided. The only solution which did not cost a prohibitive amount was the enlargement of the Oro Hondo shaft (the present main exhaust shaft) and the driving of a large cross section drift from the new air shaft to it.

Cost studies indicated that crosscuts at four levels could be driven to the air shaft location and pilot raises driven to within 1100 ft of surface, cheaper than to sink the entire distance. With these intermediate connections available, it then became possible to shut down the Oro Hondo and enlarge it while temporarily exhausting via these intermediate crosscuts through the new air shaft. After the completion of the Oro Hondo stripping the new shaft will then become downcast.

These maneuvers called for an accurate scheduling of stoping requirements by levels, so that the whole program could be completed before important tonnages had to be mined from below the 4100 level—the last adequately ventilated level.

The estimated cost of ventilating the 4100 to 5000 level interval for the mining of already developed reserves by refrigeration units showed that a third and probabaly more of the cost of a new air shaft could properly be charged against developed reserves, bringing the cost of ventilation to permit a thorough deep exploration program within reasonable limits, considering the size of the speculative target.

It is believed that Homestake has provided a flexible mining system and an adequate hoisting and ventilation system that will care for the needs of the mine for years to come, certainly beyond the time when the staff responsible for this plan will be concerned about any adverse comments made by future younger operators.

Discussion of this article sent (2 copies) to AIME before July 31, 1958, will be published in MINING ENGINEERING.

Technical Note

Study of Thorium and Uranium Minerals by X-Ray Microscopy

by S. Yamaguchi

S. YAMAGUCHI is with the Scientific Research Institute Ltd., Tokyo, Japan.
TN 459 H. Manuscript, Feb. 19, 1957.

IN this study of thorium and uranium minerals an x-ray shadow microscope of the Cosslett type[1] was used. A flux of electrons driven with a voltage

of about 10 kv was focused onto a target film of tungsten (thickness, about 1μ) by electron microscopy. The rather soft x-rays (wavelengths, 1 to 2 Å) were emitted from a point source prepared in the target film. Distance between an object plane and the target film was 2 mm, and that between the object and a photographic screen was 30 mm. Therefore, direct magnification of 15X was obtainable. The negatives were optically enlarged about seven times, bringing magnification of the final positives to about 100X.

A powder composed of thorium oxide and quartz was observed under the x-ray shadow microscope. In the micrograph obtained, Fig. 1, the dark and the semi-transparent particles correspond to ThO_2 and SiO_2, respectively. The former crystallites containing the atoms of high atomic number (90) completely absorbed the x-rays. On the other hand, the quartz particles composed of light elements were semi-transparent against the rays. An integrated area of the dark particles is proportional to the content of ThO_2 as compared with that of SiO_2. It is possible, therefore, from an x-ray shadow micrograph, to make a rough estimate of the heavy element in a powdered specimen.

Fig. 2 was observed from a mixture composed of ThO_2 and NiO crystallites (50:50 by weight). The NiO crystallites contain the rather heavy atoms. Nevertheless, the two types of particles can be discerned in this micrograph.

Figs. 3 and 4 were taken from a pulverized sample of natural monazite and a pulverized sample of uranium mineral, respectively. According to the results of chemical analysis, the sample shown in Fig. 3 and that of Fig. 4 contain about 50 pct monazite ($ThSiO_4(Ce,Y)PO_4$) and about 3 pct U_3O_8, respectively. As a matter of fact, the amount of the dark particles found in Fig. 3 is comparable with that in Fig. 2. In this way a qualitative and quantitative analysis of actinide elements found in powdered samples can be carried out by means of x-ray shadow microscopy.

Reference

[1] V. E. Cosslett and W. C. Nixon: *Journal of Applied Physics*, 1953, vol. 24, p. 616.

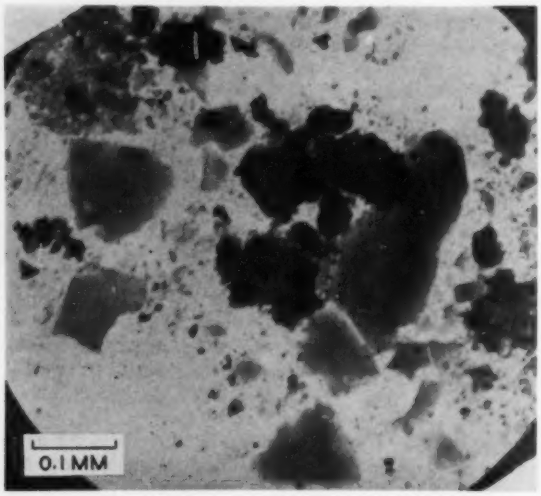


Fig. 1—X-ray shadow micrograph of ThO_2-SiO_2. Dark particles, ThO_2. Semi-transparent particles, SiO_2.

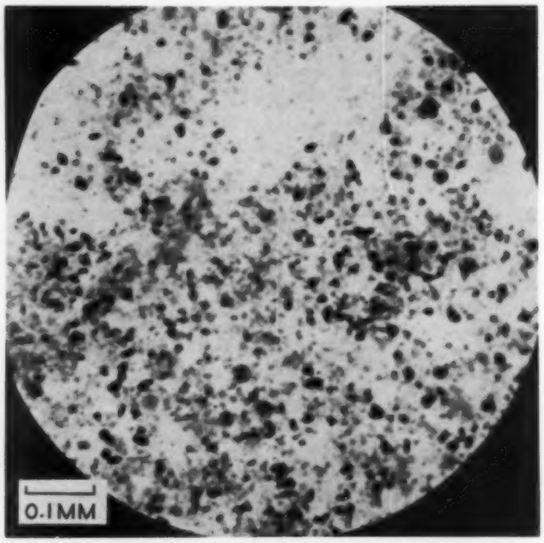


Fig. 2—Powder of ThO_2-NiO. ThO_2:NiO = 50:50 by weight.

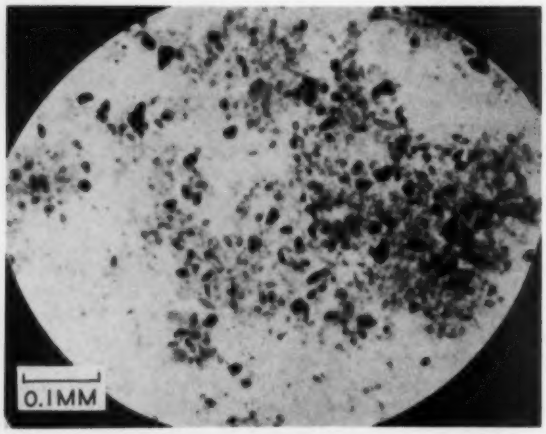


Fig. 3—Powder of natural monazite.

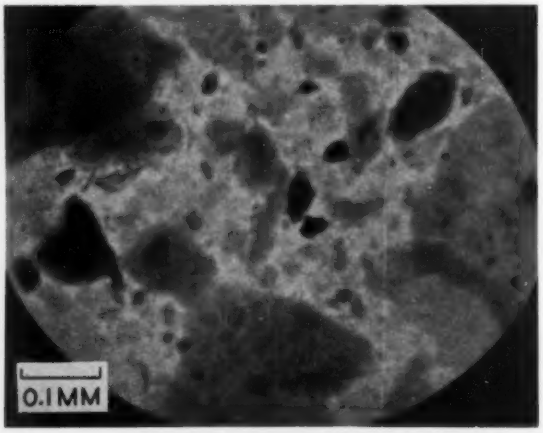


Fig. 4—Powder of uranium mineral.

Relative Effectiveness of Sodium Silicates of Different Silica-Soda Ratios as Gangue Depressants in Nonmetallic Flotation

by C. L. Sollenberger and R. B. Greenwalt

PERHAPS the most widely used dispersants or gangue depressants in nonmetallic flotation are sodium silicates, which vary in silica-to-soda ratio from 1 to 3.75. Typical manufactured silicates in order of decreasing solubility and increasing amounts of silica are *Metso*, silica-to-soda ratio of 1.00; *D*, 2.00; *RU*, 2.40; *K*, 2.90; *N*, 3.22; and *S-35*, 3.75.*

References in flotation literature[1, 2] to the use of sodium silicates are often weak because they fail to mention the type of silicate used. *Metso* and silicate *N* have occasionally been mentioned, but when the type of silicate is not mentioned, it is usually assumed to be *N*, the cheapest of the soluble silicates and the one recommended by sodium silicate manufacturers as a flotation agent.

In the Allis-Chalmers Research Laboratories a systematic study was made of the effect of different alkali-silica ratios on the concentration by flotation of two scheelite ores. One of these was a high grade ore from the Sang Dong mine in Korea. The effect of such factors as pH; addition agents; and conditioning time, temperature, and pulp density on the flotation efficiency of this ore have been described previously.[3] The other ore was a low grade ore from Getchell Mines Inc., Nevada. The mineralogy and techniques of concentrating this ore have been described by Kunze.[4] Hereafter these ores will be referred to as the Korean and Nevada ores. Experiments were made with both to determine the effect of three factors—type of silicate, concentration of silicate, and pH of the pulp—on recovery and grade of tungsten in a rougher concentrate.

Average WO_3 content of the Korean ore was 1.50 pct and of the Nevada ore 0.27 pct. The predominant tungsten mineral in both ores was scheelite, which was accompanied by a small amount of powellite. The powellite and scheelite were finely disseminated through both ores and required a −200 mesh grind for liberation. Major gangue minerals in the Korean ore, in decreasing order of abundance, were amphiboles, quartz, biotite, garnet, fluorite, and calcite. Bulk sulfides composed about 3 pct of the total weight. Gangue in the Nevada ore, in descending order of abundance, was garnet, alpha quartz, calcite, phlogopite, wollastonite, and amphiboles. Sulfide minerals were 3 to 4 pct of total weight.

Batch flotation experiments were made with 500-g samples of ore, each sample wet-ground to 90 pct passing 200 mesh. The finely ground ore was floated in a Fagergren batch cell at 25 pct solids. The natural pH of the Nevada ore was 8.9 and of the Korean ore, 8.5.

The *D*, *RU*, *K*, *N*, and *S-35* sodium silicates were obtained in colloidal dispersions with varying amounts of water. The most alkaline, *Metso*, was in dry powdered form. For convenience in addition, 5 pct solutions by weight were prepared from each of the silicates, on the basis of dry sodium silicate dissolved in the correct amount of distilled water. Chemical analyses of the various silicates are given in Table I, together with the pH of the 5 pct solutions.

A preliminary bulk sulfide float was made with secondary butyl xanthate as the collector and pine oil as the frother. The WO_3 analysis of the sulfide concentrate was nearly 1 pct for the Korean ore and about 0.1 pct for the Nevada ore. The tungsten contained in the sulfide concentrate constituted about 3 pct of the total tungsten in each ore. No effort was made to recover these tungsten values. The scheelite was floated with oleic acid. Adjustments in pH were made with sulfuric acid or sodium carbonate. A 1 pct solution of 85 pct Aerosol OT was sprayed on the froth and sides of the cell during the scheelite float to aid in dispersing the minerals and to decrease the entrapment of gangue particles.

Six tests were planned for each of the six types of silicate in which concentrations of 1, 2, and 4 lb of silicate per ton of dry ore were investigated at both 6.5 and 10 pH. All tests were made at room temperature. The performance of each silicate was judged from the grade and recovery of WO_3 in the scheelite rougher concentrate. Tungsten recovery was calculated on the basis of the scheelite remaining in the ore after the preliminary sulfide float. Testing of each silicate at three levels of concentration and two levels of pH required 36 tests with each scheelite ore. Variance analyses were performed on the concentrate grades and recoveries to determine whether or not the type of sodium silicate, the concentration of sodium silicate, or the pH significantly affected recovery or grade.

Results

Concentrate Grade: A variance analysis of the concentrate grades for the Korean ore showed that concentration of the silicate and pH of the ore pulp were major factors in producing a high grade concentrate. Also, the silica-to-soda ratio was important as an interaction with pH. The concentrate grade vs silica-to-soda ratio is plotted in Fig. 1. The curves show that the concentrate grade improved with an increase in concentration of sodium silicate and also

C. L. SOLLENBERGER, Member AIME, is Supervisor of Mechanical and Process Research, Research Laboratories, Allis-Chalmers Mfg. Co., Milwaukee. R. B. GREENWALT, formerly with the Allis-Chalmers Research Laboratories, is now with Arthur G. McKee & Co., Cleveland, Ohio.

TP 4745B. Manuscript, March 20, 1957. New Orleans Meeting, February 1957.

* All registered trade marks of the Philadelphia Quartz Co.

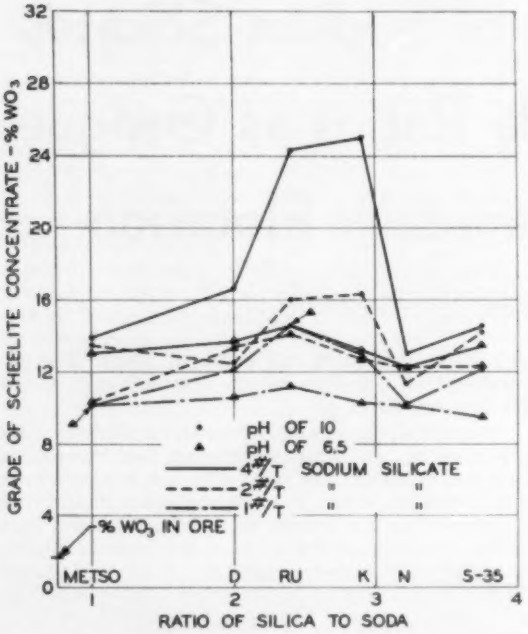


Fig. 1—Korean ore concentrate grade vs silica-to-soda ratio.

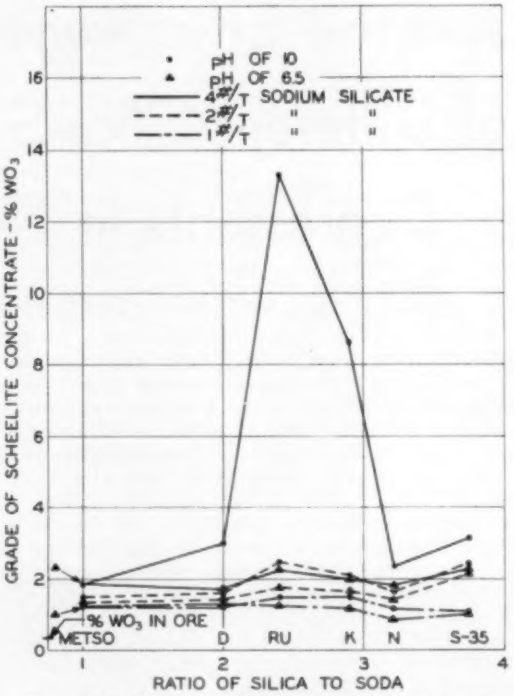


Fig. 2—Nevada ore concentrate grade vs silica-to-soda ratio.

with an increase in pH. The silica-to-soda ratio significantly affected concentrate grade only at pH 10. At this pH the sodium silicates of ratios 2.40 and 2.90 (*RU* and *K*) performed much better than the other silicates. At a concentration of 4 lb per ton, concentrate grades with these silicates were much superior to those obtained with the other silicates. The grades were respectively 24.3 and 25.0 pct WO_3 as compared to 13.0 pct WO_3 obtained with *N* sodium silicate with the same conditions of silicate concentration and pH.

The variance analysis of the grades for the Nevada ore showed that only the concentration of the silicate significantly affected the rougher concentrate grade at all levels of the other variables (the only significant main effect). However, in this analysis the residual was large, indicating either a large experimental error or a significant second order interaction (interaction of all three variables—silica-to-soda ratio, concentration, and pH). The grades are plotted vs silica-to-soda ratio in Fig. 2. The effect of concentration of the silicate can be seen on these curves. The grade increased as the concentration of sodium silicate increased, as before. Fig. 2 shows a remarkable increase in grade with silicates *RU* and *K* at pH 10 and a concentration of 4 lb per ton. These were the conditions at which maximum grades were also obtained with the Korean ore. With the Nevada ore, the grades with the *RU* and *K* silicates were 13.3 and 8.66 pct WO_3, respectively. With sodium silicate *N* and identical conditions, concentrate grade for the Nevada ore was 2.36 WO_3. Apparently the second order interaction was highly significant. Replication of the six tests at pH 10 and 4 lb per ton and a variance analysis of the replicated tests showed the silica-to-soda ratio to be highly significant at this particular pH and silicate concentration.

Recovery: Recoveries for all tests were above 88 pct and for most of them were greater than 95 pct of the contained WO_3. The high grade rougher concentrates produced with the *RU* and *K* sodium silicates contained 99 pct of the WO_3 in the Korean ore and 93 to 94 pct of the WO_3 in the Nevada ore. Recoveries of 90 pct from the Korean ore and 93 pct from the Nevada ore were obtained with sodium silicate *N* at the identical silicate concentration and pH. Apparently the great improvements in grade were obtained at no loss in recovery.

Additional Experiments

The superiority of the *RU* and *K* silicates over the other silicates in obtaining a high grade WO_3 con-

Table I. Chemical Analyses of the Sodium Silicates*

Brand of Sodium Silicate	Percent by Weight		Approximate Ratio of SiO_2 to Na_2O	Condition as Received	Price per 100 Lb of Dry Silicate, $**	pH of 5 pct Solution
	Na_2O	SiO_2				
Metso Granular	29.1	28.7	1	dry powder	7.10	12.0
D	15.1	30.2	2	colloidal dispersion	5.08	11.5
RU	13.8	33.1	2.40	colloidal dispersion	4.91	11.2
K	11.0	31.9	2.90	colloidal dispersion	4.55	11.0
N	8.9	28.7	3.22	colloidal dispersion	3.59	10.8
S-35	6.8	25.3	3.75	colloidal dispersion	5.45	10.7

* Furnished by Philadelphia Quartz Co.
** May 1955.

centrate implied that an intermediate silica-to-soda ratio or a combination of the two silicates might lead to even better results. Several additional experiments were made with a 1:1 mixture of *RU* and *K* as the gangue depressant. The mixture had an average silica-to-soda ratio of 2.65. The pulp pH was maintained at 10, but the mixture was added in amounts of 1, 2, 3, and 4 lb per ton. The experiments were run with both ores. In Fig. 3 plots of concentrate grade vs sodium silicate concentration are compared with the previous results for *RU*, *K*, and *N* silicates. A continuous increase in grade was obtained with all silicates as concentration increased. The curves show that the *RU* and *K* mixture was superior to *N* and better than either *RU* or *K* alone. The highest concentrate grades from the two ores were obtained with the 2.65 ratio at a concentration of 4 lb per ton. These grades were 28.5 and 15.7 pct WO_3 respectively for the Korean and Nevada ores. Corresponding recoveries were 89.4 and 96.4 pct. All data were obtained with a single-stage rougher float. Undoubtedly these grades could be improved with successive cleaner floats.

To determine whether or not the improvement in concentrate grade achieved with the *RU* and *K* mixture could be obtained with ores other than scheelite, additional experiments were made with two ores amenable to an oleic acid-sodium silicate float, a specular hematite ore, and a uranium ore. Several floats were made with each ore with the *RU* and *K* mixture to find conditions that produced a good concentrate. The best experiment was repeated with silicate *N* substituted for the *RU* and *K* combination. The hematite concentrate with the *RU* and *K* mixture analyzed 56 pct acid-soluble iron (head analysis 36.6 pct) and contained 89 pct of the iron in the feed. With silicate *N* the grade was 50.5 pct Fe and recovery 87 pct. The uranium ore concentrate with the *RU* and *K* mixture analyzed 0.56 pct equivalent U_3O_8 (head analysis 0.13 pct) and recovery was 71.0 pct. With silicate *N* the concentrate grade was 0.38 pct equivalent U_3O_8 and recovery 67 pct. Many more floats would have to be made for the above comparisons to be made at the proper silicate concentration and pH, but the results indicate that an improvement in concentrate grade can be obtained with the *RU* and *K* mixtures with these ores.

Cost of the Silicates

Prices in Table I show that with the exception of *S-35* the price per pound of dry silicate increases as the silicate becomes more alkaline, silicate *N* being the cheapest. Silicates *K* and *RU*, however, are next to *N* in order of increasing cost per pound.

Conclusions

1) In the rougher flotation of two scheelite ores, remarkably high concentrate grades and ratios of concentration can be obtained by selecting the proper sodium silicate, concentration of silicate, and pH.

2) Silicates having silica-to-soda ratios of 2.40 and 2.90 (*RU* and *K*) at a silicate concentration of 4 lb per ton and a pH of 10 produced the highest grades and ratios of concentration.

3) Even better results were obtained when a 1:1 mixture of these two silicates was used at the same concentration and pH. With the mixture, concentrate grade and ratio of concentration for the Nevada ore were six times greater than when silicate *N* was used, and for the Korean ore two times greater than when *N* was used.

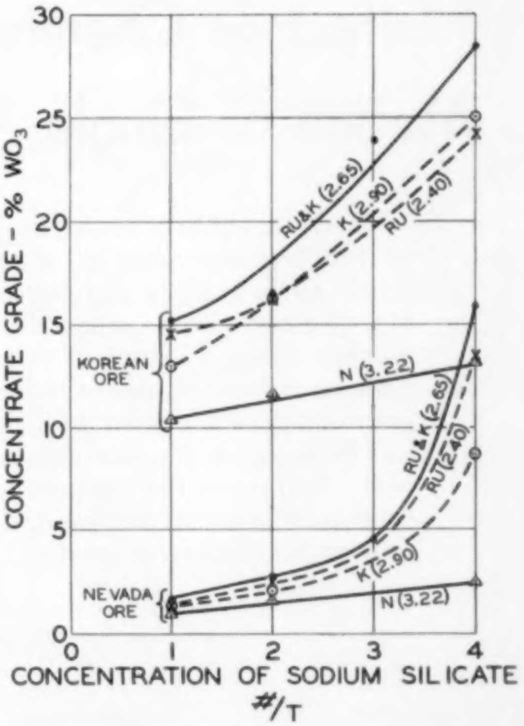


Fig. 3—Concentrate grade vs sodium silicate concentration for various sodium silicates. Numbers are ratio of SiO_2 to Na_2O.

4) These improvements were obtained with no loss in recovery.

5) At lower concentrations or at 6.5 pH, the silica-to-soda ratio had either no significant effect on concentrate grade or the improvement was much less remarkable. This indicates the necessity of determining the proper operating pH as well as the right combination of alkali-silica and the proper concentration.

6) Similar improvements in grade were found when the *RU-K* silicate mixture was used with specular hematite and uranium ores.

No effort has been made here to predict the reactions occurring in the pulp which allow much better elimination of siliceous gangue from the rougher concentrate when silicates *RU* and *K* are used at the proper concentration of silicate and pH. The chemistry of the soluble silicates is complex. Perhaps the *RU* and *K* silicates more effectively disperse the gangue or more effectively wash the slimes from the tungsten minerals, or perhaps the molecular cross section of the silicates is important in blocking the oleic acid collector from the gangue mineral. In any event, the type of silicate can be of great importance and the optimum ratio should be investigated along with the silicate concentration and pH when a flotation study is conducted.

References

[1] J. C. Vail: *Soluble Silicates*, vol. 2, p. 118. Reinhold Publishing Co., New York, 1952.

[2] *Silicate P's and Q's*, vol. 19, no. 11, 1939. Published by Philadelphia Quartz Co., Philadelphia, Pa.

[3] W. Mitchell, Jr., C. L. Sollenberger, and T. G. Kirkland: Flotation Tests on Korean Scheelite Ore. *AIME Trans.*, 1951, vol. 190.

[4] K. Kunze: Milling Tungsten Ores at the Getchell Mines. *Mining Congress Journal*, 1953, vol. 39, p. 31.

Discussion of this paper sent (2 copies) to AIME before July 31, 1958, will be published in MINING ENGINEERING.

Effect of Chemical Reagents on the Motion of Single Air Bubbles in Water

The effect of bubble size and concentration of certain reagents on the terminal velocity, shape, path, and drag coefficients of single air bubbles in distilled water has been investigated. Bubbles of a certain size range rise considerably faster than Reynolds number—drag coefficient relationships predict, whereas a small amount of frothing agent reduces their terminal velocity. The rapid velocity at which bubbles rise in distilled water appears to result from slip at the boundary and from circulation within the bubbles. Surface-active agents retard bubble motion through prevention of both circulation and slip at the boundary. A surface tension concentration gradient helps maintain bubble sphericity.

by D. W. Fuerstenau and C. H. Wayman

THE gas phase is one of the indispensible ingredients in flotation operations. Flotation depends on the collision of an air bubble and a mineral particle in a pulp and their ability to remain in contact long enough for adherence to take place. Before it is possible to understand the mechanics of air bubble-mineral particle encounter, it is necessary to learn more about the nature of bubbles themselves before collision with a mineral particle has taken place. To date, little work has been done on air bubbles in flotation systems. In 1945 Fahrenwald[1] presented a study of the role of frothers on air bubbles and on aeration in flotation, and recently Wark and Sutherland[2] discussed the work of Rosenberg[3] in relation to flotation. The research reported in this present article was undertaken to investigate systematically the effect of bubble size and the concentration of certain reagents on the terminal velocity, shape, path, and drag coefficient of single bubbles in distilled water. Most of the work is concerned with the effect of α-terpineol on bubble motion in water, but studies were made with potassium chloride, potassium hydroxide, potassium ethyl xanthate, and potassium amyl xanthate.

Experimental Method and Materials: To obtain free bubble rise and reduce wall and surface effects, the investigators used a tank of 5½x5½x30-in. internal dimensions, filled with water to within 4½ in. of the top.[4] The tank was made of acrylic plastic so that the walls would have good optical properties.

Distilled water, which was re-distilled in a block tin still and saturated with air before each test, was used in all the experiments. All solutions were made with reagent-grade chemicals. During each experiment the water was at room temperature, and during the course of an experiment the temperature did not fluctuate more than 0.5°C. Since the experiments were performed over a period of six months, the temperature varied between 25° and 27°C. The temperature at which each series of experiments was conducted is recorded with the data.

The experimental apparatus is presented diagrammatically in Fig. 1. Individual air bubbles were generated from purified compressed air through a capillary of 0.003-cm internal diameter at a rate

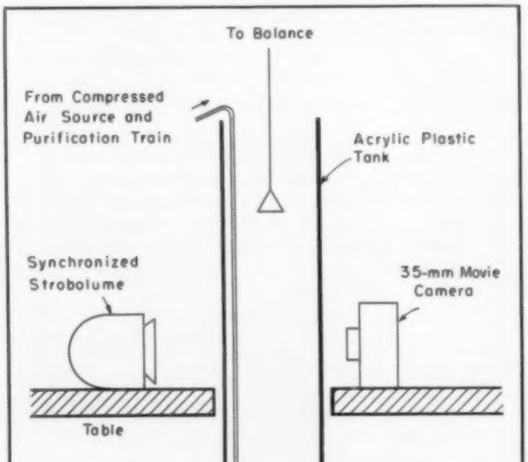


Fig. 1—Experimental apparatus for measuring terminal velocities of air bubbles in water.

D. W. FUERSTENAU, Junior Member AIME, formerly Assistant Professor, Department of Metallurgy, Massachusetts Institute of Technology, is with the Metals Research Laboratories, Electro Metallurgical Co., Niagara Falls, N. Y. C. H. WAYMAN, Junior Member AIME, is Research Assistant, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

TP 4746B. Manuscript, Aug. 20, 1956.

that kept the individual bubbles about 2 ft apart. Under these conditions the bubbles always had a radius of 0.049 cm, not only in distilled water but also in solutions containing terpineol. Bubble sizes were determined in two different manners: 1) by measuring directly from a photograph and 2) by coalescing a hundred bubbles or more and weighing the resultant large bubble in a submerged cup. It might be added that coalescing the bubbles in solutions containing 22 mg of terpineol per liter was a difficult job. All bubbles larger than 0.049-cm equivalent radius were formed by coalescing a given number of the 0.049-cm bubbles and calculating the size. Each large bubble was formed in a small glass cup that could be dumped with a magnet. Proper positioning of the cup insured that the path of the bubble was in focus on the film in the camera. Smaller bubbles were formed by moving the capillary sideways to shear off small bubbles, one of which would be caught under the cup. The size of this bubble was measured directly from the film.

Bubbles which were photographed about 15 in. from their point of release were found to be at their terminal velocity. Shape, velocity, and path of the bubbles were determined photographically with a 35-mm movie camera, using an average speed of about 35 frames per sec. Film speeds were measured with a small neon light that flashed onto the film at a known rate through a pinhole in the back of the camera. A glass rod photographed in the plane of the rising bubbles provided a means to calibrate distance and bubble size on the film. Light for taking the pictures came from a General Radio type 1532-B Strobolume that was synchronized with the camera.

To ascertain bubble velocity, the vertical displacement of the bubble on the film was measured. Bubble speeds were calculated from the vertical displacement, scale factor, and film speed. In certain instances, bubbles spiral to the surface. Under these conditions, actual velocity might be somewhat greater than the measured vertical velocity.

Experimental Results

In describing the dimensions of a solid sphere, it is convenient to use its radius. However, to describe a fluid body that is constantly changing shape, it is convenient to use a parameter based on volume, namely, the equivalent radius, r_e, which is the radius of a sphere of a volume equal to that of the fluid body.

$$r_e = \sqrt[3]{\frac{\text{volume}}{\frac{4}{3}\pi}} \qquad [1]$$

For bubbles rising at their terminal velocity, v_t, the drag coefficient, C_D, can be written as

$$C_D = \frac{(8/3)\, g\, r_e\, (\rho_1 - \rho_2)}{v_t^2} \qquad [2]$$

and the Reynolds number, N_R, can be written as

$$N_R = \frac{2\, r_e\, v_t\, \rho_1}{\eta_1} \qquad [3]$$

where ρ_1 is the density of the fluid (1 g per cc for water), ρ_2 is the density of the fluid bubble (0.0013 g per cc for air), η_1 is the viscosity of water.

Terminal Velocity of Single Bubbles: The terminal velocities of single bubbles were measured to ascertain how the presence of a frothing agent may affect the motion of a bubble. In these experiments terminal velocities were measured as a function of bubble size and frother concentration. Within a certain size range (see Table II) bubbles rise in a wobbling, helical manner, and actual bubble velocity may be somewhat higher than the vertical velocity measured by the present techniques. Bubble sizes were varied from 0.019 to 0.94-cm equivalent radius, and the concentration of terpineol was maintained at four different concentrations (0, 3.7, 7.3, and 22 mg of terpineol per liter of distilled water). The experiments with solutions containing 3.7 mg terpineol per liter were run at 26.5 ± 0.5°C and the remainder were run at 25 ± 0.5°C. In Fig. 2, terminal velocity is plotted logarithmically as a function of equivalent radius. It can be seen from Fig. 2 that the terminal velocity of bubbles in conductivity water increases sharply to about 35 cm per sec as the bubble size is increased to 0.065-cm radius. Further increase in bubble size reduces the terminal velocity somewhat until bubbles with an equivalent radius of 0.30 cm have a terminal velocity of only 23 cm per sec before the velocity again increases with bubble size.

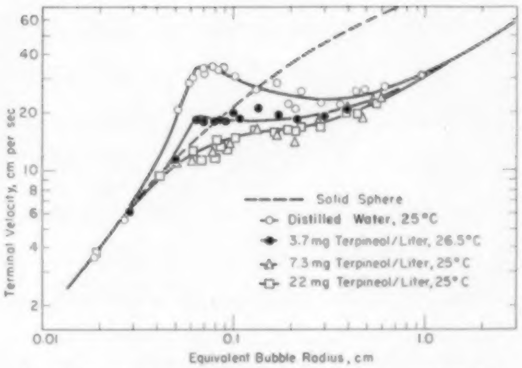


Fig. 2—Terminal velocity of single air bubbles in conductivity water and aqueous terpineol solutions as a function of bubble size.

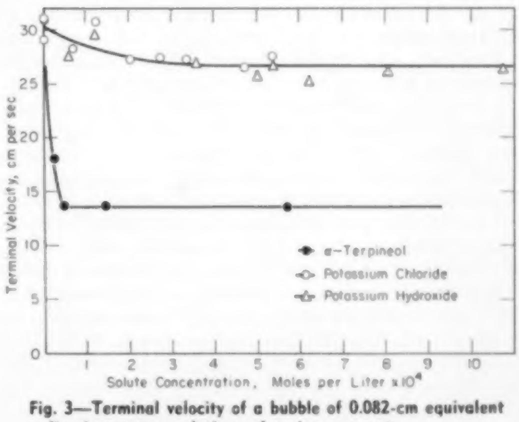


Fig. 3—Terminal velocity of a bubble of 0.082-cm equivalent radius in aqueous solutions of various reagents.

The presence of only 3.7 mg of terpineol per liter reduces the terminal velocity of bubbles in the size range between 0.03 and about 0.4-cm equivalent radius. Bubbles with a radius of 0.065 cm, at which size the velocity reduction is greatest, rise 18.5 cm per sec in solutions of 3.7 mg of terpineol per liter. In solutions containing 7.3 and 22 mg terpineol per

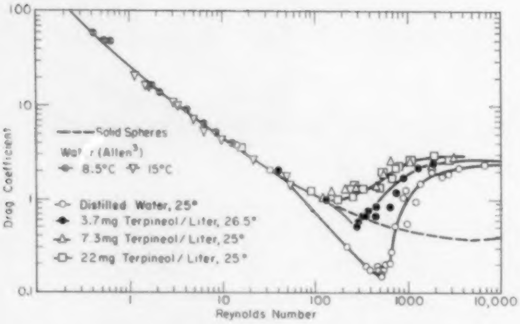


Fig. 4—Drag coefficient as a function of Reynolds number for air bubbles rising at their terminal velocity in water and in aqueous solutions of α-terpineol.

liter, a bubble of 0.065-cm radius rises at 12.5 cm per sec, which is only 36 pct of a bubble's velocity in distilled water.

To study the differences in behavior of single bubbles in aqueous solutions of heteropolar reagents and inorganic electrolytes, the terminal velocity of a bubble of 0.082-cm equivalent radius was measured as a function of the concentration of KCl, α-terpineol, and KOH. This bubble size was chosen because it was intermediate and because a bubble of this particular size not only rises at nearly maximum velocity but also is an oblate spheroid in distilled water. KCl was chosen as a reagent because it represents a typical inorganic electrolyte, but KOH was chosen because air bubbles are reputed to be negatively charged in water[5] and only adsorption of hydroxyl ions at the surface could account for this. If hydroxyl ions play a role in the surface properties of air bubbles, the addition of KOH to the system might affect their movement. Observation of the experimental data presented in Fig. 3 will show that terpineol markedly reduces the terminal velocity of 0.082-cm radius bubbles about 55 pct, whereas KCl and KOH reduce the velocity only about 10 pct. There is no significant difference between the effect of KOH and KCl. In each case, velocity reaches a certain minimum and is reduced no further.

Non-Dimensional Presentation of Data for Single Bubbles: In Fig. 4 the data are presented non-dimensionally, the drag coefficient C_D being plotted as a function of the Reynolds number, N_R, of the bubble. For comparative purposes, Allen's[6] experimental data for very small bubbles and the curve for solid spheres are plotted in Fig. 4 also. In distilled water, air bubbles behave as solid spheres when the Reynolds number is less than 40 even though bubbles remain spherical up to Reynolds numbers of 400. However, in the presence of a small amount of frother, air bubbles behave as solid objects until the Reynolds number exceeds 130. The drag coefficient of bubbles in conductivity water becomes less than that for solid spheres as the Reynolds number increases from 40 to 500, reaching a minimum of 0.15. Upon further increase in the Reynolds number, the drag coefficient increases sharply and approaches a constant value of about 2.6.[3] In solutions containing 3.7 mg of terpineol per liter of water, the drag coefficient has a minimum value at a Reynolds number of 300, this minimum being only slightly lower than that for solid spheres. In the presence of more terpineol, the drag coefficient is equal to that of solid spheres up to Reynolds numbers of 130 but is always greater than that for solid spheres when the Reynolds number exceeds 130. The drag coefficient for single bubbles approaches a constant value of about 2.6, independent of the terpineol concentration.

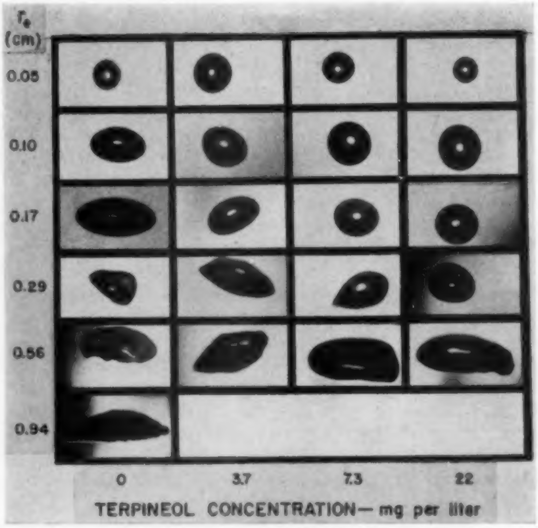


Fig. 5—Effect of terpineol concentration and bubble size on bubble shape. (Photographs made at various magnifications.)

Bubble Shapes: Small bubbles are spherical, but as the size increases, the bubbles become increasingly flattened and change to oblate spheroids. The size at which bubbles change to oblate spheroids depends on the concentration of frothing agent. Upon further increase in size, the bubbles become increasingly flattened and begin to oscillate. When the shape begins to fluctuate rapidly, the bubbles appear to be distorted oblate spheroids with jagged corners and edges. The size at which bubbles change to distorted oblate spheroids does not depend greatly on terpineol concentration. Table I presents, for the different concentrations of terpineol in distilled water, the sizes at which bubbles flatten into oblate spheroids and begin to fluctuate, forming distorted oblate spheroids. As bubbles continue to increase in size, they become increasingly distorted, fluctuating violently in shape until pressure gradients cause them to assume the shape of so-called spherical caps at an equivalent radius of about 0.9 cm.[3] The upper surface of such bubbles is essentially spherical, whereas the lower surface varies from a highly irregular surface for liquids of low viscosity to a smooth surface in very viscous fluids.[4] Spherical cap bubbles retain their shape as they rise. Bubbles considerably larger than spherical caps be-

Table I. Effect of Terpineol Concentration on Size and Reynolds Number at which Air Bubbles Distort

Concentration of Terpineol, Mg per Liter	Conditions at which Bubbles Begin to Flatten into Oblate Spheroids		Conditions at which Bubbles Become Distorted Oblate Spheroids	
	Radius, Cm	Reynolds Number	Radius, Cm	Reynolds Number
0	0.065	400	0.20	950
3.7	0.065	300	0.20	800
7.3	0.12	400	0.29	800
22	0.20	500	0.29	1100

come doughnut-shaped, and exceedingly large bubbles break up.

The photographs of bubbles presented in Fig. 5 illustrate the effect of bubble size and frother concentration on bubble shapes. It should be pointed out that the magnification of bubbles in each of the pictures presented in Fig. 5 was not held constant in making the photographs. Bubbles of five different sizes were selected for comparison in solutions containing the different terpineol concentrations. One large bubble (0.94-cm equivalent radius) in distilled water is shown to illustrate the spherical cap. In Fig. 6 three successive pictures of three different bubbles are presented (0.22, 0.56, and 0.94-cm equivalent radius) to illustrate how distorted bubbles change shape rapidly. Each picture is about 1/35 sec apart. The spherical cap essentially maintains its shape, whereas the distorted oblate spheroids change shape rapidly. Small bubbles are not shown because they do not change shape while rising.

Bubble Paths: Bubbles were found to rise with three different paths or motions: 1) rectilinear path, 2) helical or spiraling path, and 3) rectilinear rocking motion. As the bubble size increases, there is a change from a rectilinear path to a helical path. This change is not accompanied by a change in bubble shape. Spiraling begins and increases in amplitude and frequency until a maximum is reached.

Table II. Motions with which Bubbles of Different Sizes Rise in Aqueous Solutions of Terpineol

Motion or Path of Rising Air Bubbles	Size Range (Equivalent Radius, Cm) in which Bubbles Rise in Given Path for Different Concentrations of Terpineol, Mg per Liter			
	0	3.7	7.3	22
Rectilinear	<0.08	<0.07	<0.06	<0.06
Helical	0.08 to 0.20	0.07 to 0.20	0.06 to 0.09	0.06 to 0.09
Wobbling helical	Absent	Absent	0.09 to 0.21	0.09 to 0.22
Rocking rectilinear	0.20 to 0.8	0.20 to 0.8	0.21 to 0.8	0.22 to 0.8
Rectilinear	>0.8	>0.8	>0.8	>0.8

Bubbles rising with a small amplitude and high frequency of spinning often rise in a large spiral. Such motion has been termed *wobbling helical motion*. When bubbles are large enough to become distorted oblate spheroids, they rise in a rectilinear path, but the rapid change in bubble shape causes the motion to appear as rocking rectilinear. By the time bubbles form spherical caps, they do not change shape and appear to rise in a rectilinear path. In solutions containing terpineol, the largest bubble was 0.60-cm equivalent radius; however, it seems that spherical caps in such solutions will rise in the same manner as they do in distilled water. Table II gives the size range (equivalent radius in centimeters) in which the bubbles rise—with the different types of motion—for solutions containing 0, 3.7, 7.3, and 22 mg of terpineol per liter of distilled water.

Effect of Different Reagents on Shape and Terminal Velocity of Single Bubbles: In part of this investigation, the effect of potassium chloride, potassium hydroxide, terpineol, potassium ethyl xanthate, potassium amyl xanthate, and mixtures of terpineol and xanthate on the shape and terminal velocity of bubbles of 0.082-cm equivalent radius was studied. The data are presented in Table III.

Observation of Table III reveals that any molecule or ion with a long enough hydrocarbon chain

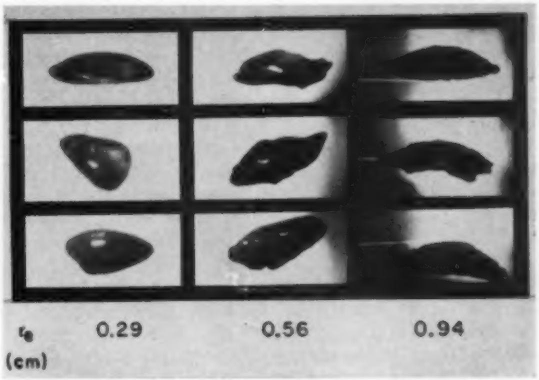


Fig. 6—Illustration of the rapid distortion of rising bubbles in conductivity water. Film speed, about 35 frames per sec.

can affect the shape and terminal velocity with which an air bubble rises in water.

Discussion of Results

The unusual behavior of bubbles in distilled water in the presence or absence of a small amount of surface-active agent must depend on gas-liquid interfacial phenomena, since those surface-active reagents which affect bubble motion are known to be strongly adsorbed at the gas-liquid interface.[4,7,8] The strong interaction of water molecules with each other probably contributes to the unusually rapid velocity of rising air bubbles in distilled water.

For fluid spheres at Reynolds numbers less than 1, Hadamard[9] and Rybczynski[10] have shown theoretically that fluid spheres moving through another fluid will circulate in the form of a vortex ring. The existence of circulation in drops has vividly been demonstrated by Garner.[11] The Hadamard-Rybczynski correction to Stokes' law states that a fluid sphere of low viscosity moving in a fluid of high viscosity should move 1.5 times as fast as a solid sphere because of internal circulation, but these concepts do not seem to apply to small air bubbles, which rise in distilled water at the velocity predicted by Stokes' law. Furthermore, they behave as solid spheres up to a Reynolds number of about 40, or a bubble radius of 0.025 cm. But the terminal velocity of bubbles larger than 0.025 cm in radius increases rapidly over that of a solid sphere until at the maximum, where bubbles begin to flatten, the terminal velocity is 2.3 times that of a solid sphere. In their derivations, Hadamard and Rybczynski assumed no slip to exist at the boundary. Since water molecules are strongly attracted to each other within the liquid through dipole interactions (the energy of association of water dipoles in the liquid state being about 6 kcal per mole[12]) but are attracted only weakly to the bubble, water molecules would have such an affinity for themselves that they would tend not to travel with the bubble in distilled water. Consequently, the existence of slip at the air-distilled water interface seems reasonable.[3,4,13] In the case of nearly all solids, water molecules are strongly held to the surface and shear must take place within the liquid during movement of the solid.

If a heteropolar organic compound is dissolved in the water, adsorption of these molecules takes place at the air-liquid interface in such a way that the hydrocarbon chain sticks into the gaseous phase, the

polar head remaining in the water. Thus, when an air bubble moves through a dilute aqueous solution of terpineol, the terpineol molecules move with the bubble (in a manner similar to the movement of a sailboat on water). Since water molecules are held to the polar group of the surface-active reagent, they travel with the bubble and movement of a bubble in a dilute aqueous solution containing the surface-active agent would be similar to the movement of a solid sphere through water because water molecules now travel with the bubble. Before a surface-active agent can affect bubble motion, its hydrocarbon chain must be long enough for adsorption and desorption to take place relatively slowly. For example, amyl xanthate ions retard bubble rise, whereas ethyl xanthate ions do not affect it appreciably (Table III).

Table III. Effect of Various Reagents on Shape and Terminal Velocity of Bubbles with an Equivalent Radius of 0.082 Cm

Aqueous Solution	Bubble Shape	Terminal Velocity, Cm per Sec
Distilled water	Oblate spheroid	31
KOH, 7 mg per liter	Oblate spheroid	29
20 to 60 mg per liter	Oblate spheroid	27
KCl, 9 mg per liter	Oblate spheroid	30
15 to 40 mg per liter	Oblate spheroid	27
Terpineol, 3.7 mg per liter	Slightly flattened spheroid	18
7 to 88 mg per liter	Spheroid	14
Potassium ethyl xanthate, 20 mg per liter	Oblate spheroid	27
Potassium amyl xanthate, 25 mg per liter	Oblate spheroid	21
20 mg of potassium ethyl xanthate plus 3.7 mg terpineol per liter	Slightly flattened oblate spheroid	16
25 mg of potassium amyl xanthate plus 3.7 mg terpineol per liter	Spheroid	14

If a bubble rising in a dilute aqueous solution of terpineol is to rise no faster than a solid sphere, both slip at the boundary and circulation must be diminished. Following the concepts of Frumkin and Levich,[18] Sutherland and Linton[14] have recently showed how surface-active agents prevent internal circulation in fluid drops, which are similar to air bubbles. If there is no slip at the boundary between a bubble and the liquid, the surface of a rising bubble experiences a tangential force τ_0 that is proportional to the viscosity of the liquid η and to the velocity gradient normal to the surface:

$$\tau_0 = \eta \left(\frac{\partial v}{\partial y} \right)_{y=0} \qquad [4]$$

This tangential force is responsible for circulation. If an air bubble behaves as a solid sphere, it is possible to calculate the maximum stress at the surface. On a solid sphere the stress varies from zero at the front of the sphere to a maximum at 57° and falls to zero behind its equator.[15] The maximum stress is

$$\tau_0 = 2.21 \, v_t^{3/2} \, (\eta \rho / d)^{1/2} \qquad [5]$$

where ρ is the density of the continuous phase, d the diameter of the sphere, and v_t the terminal velocity of the sphere. Bubbles of 0.065-cm radius rising at a terminal velocity of 12 cm per sec in an aqueous solution containing 7 mg or more of terpineol per liter ($\eta = 0.01$ poise and $\rho = 1$ g per cm^3) have a maximum stress of 26 dynes per cm^2. Prevention of internal circulation in a bubble can arise only through the existence of a force that opposes the shear stress. Such an opposing force might result from the surface-tension gradient, which can be produced in solutions of a surface-active reagent. The mechanism by which a surface-tension gradient might arise is the streaming of frother molecules towards the bottom of a rising bubble. The higher surface pressure of the compressed layer of adsorbed molecules at the rear of a rising bubble will try to spread the molecules back again and will consequently oppose flow along the surface. Adsorption at the front of the bubble and desorption at the rear will have to be slow, however, in order to maintain the surface-tension gradient. The surface stress that opposes the tangential frictional stress is determined by the surface-pressure gradient $\frac{\partial \pi}{\partial S}$, where π is the difference in surface tension between the back of the bubble where the layer of adsorbed terpineol molecules is compressed and the front of the bubble where the surface concentration is reduced, or may even approach zero, at a circumferential distance S.

For the bubble described above, an average tangential stress of about 20 dynes per cm^2 might be expected if circulation is to be prevented.[17, 18] Therefore the surface pressure must vary by about 20 dynes per cm per centimeter of circumferential distance. For the above bubble, the circumferential distance from the front to the point of flow separation, which is about 110° from the front of the bubble,[15] is 0.11 cm. Hence a surface pressure difference of 2.2 dynes per cm would be necessary to prevent circulation. Use of the Gibbs equation to calculate adsorption densitites from a surface tension-concentration curve shows that 2×10^{-11} mole of terpineol is adsorbed per square centimeter of surface from solutions containing 7.3 mg terpineol per liter. To produce the requisite value of π, the terpineol molecules toward the rear of the bubble need be crowded only until the adsorption density is 8×10^{-11} mole per cm^2 if the front of the bubble is devoid of terpineol molecules.

Bubbles flatten, and consequently slow down, because the mechanical forces acting on the bubble overcome the effect of surface tension, which tends to keep the bubble spherical. However, a surface tension-concentration gradient can assist in maintaining a bubble's spherical shape by counteracting the surface stress as outlined in the previous paragraph. By increasing the concentration of terpineol in solution, the magnitude of the possible surface-tension gradient is increased. Furthermore, if bubbles are momentarily distorted as they rise, the surface stretches and forms fresh surface devoid of terpineol molecules. Hence, the new surface momentarily has a slightly higher surface tension, which acts like a spring parallel to the surface, tending to pull the bubble back into spherical shape. Stretching the bubble in distilled water does not give rise to a concentration gradient at the surface, and hence no such *spring* works, because the surface tension remains constant. For this spring effect to take place, adsorption of the surface-active agent must be slow. Once the external forces attempting to flatten the bubble become too great, circulation within the bubble sets in and the bubble begins to distort and oscillate violently.

From a molecular point of view, it seems as though all bubbles circulate in distilled water in the

absence of a surface-active agent. However, at Reynolds numbers below 40, bubbles act as solid spheres even in distilled water. This phenomenon has not yet been reconciled.[4]

Air Bubbles in Flotation: Using a 1-cu ft Massco-Fahrenwald flotation machine, Fahrenwald[1] found the average bubble radius to be 0.2, 0.11, and 0.07 cm in solutions containing 0, 3.1, and 4.6 mg of terpineol per liter. Sutherland[16] found the average radius to be 0.09, 0.07, and 0.03 cm, considering a weighted volumetric average in a 2000-g Denver subaeration flotation machine containing 2.5, 5, and 10 mg of terpineol per liter of water. There certainly will be a difference in bubble size depending on conditions within flotation machines, but the size range appears to be in the range wherein the terminal velocity of bubbles is markedly affected by frother concentration. Since bubbles rise more slowly in solutions containing surface-active agents, there will be two or three times as many chances for bubble-particle collision in the presence of a frother. Furthermore, bubbles are smaller in the presence of a surface-active agent (because small bubbles do not coalesce during their formation), and this means that the large distorted bubbles which oscillate violently should be absent in a subaeration flotation machine. The rapid oscillations of bubbles would probably repel any impinging mineral particle from the bubble surface. To find out the properties of bubbles in systems more similar to flotation conditions, work is under way to study the motion of bubbles in swarms.

Acknowledgment

This investigation was carried out in the Richards Mineral Engineering Laboratories, Massachusetts Institute of Technology, under the sponsorship of the U. S. Atomic Energy Commission. The authors wish to acknowledge the assistance of A. M. Gaudin, R. J. Charles, and K. L. Sutherland.

References

[1] A. W. Fahrenwald: *Engineering and Mining Journal*, October 1945, vol. 146, p. 94.

[2] K. L. Sutherland and I. W. Wark: *Principles of Flotation*, Institute of Mining and Metallurgy, Melbourne, Australia, 1955.

[3] B. Rosenberg: The Drag and Shape of Air Bubbles Moving in Liquids. Navy Department, The David W. Taylor Model Basin, *Report 727*, 1950.

[4] W. L. Haberman and R. K. Morton: An Experimental Investigation of the Drag and Shape of Air Bubbles Rising in Various Liquids. Navy Department, The David W. Taylor Model Basin, *Report 802*, 1953.

[5] W. A. Gortner: *Outlines of Biochemistry*. John Wiley & Sons, New York, 1949.

[6] H. S. Allen: *Philosophical Magazine*, 1900, vol. 50, pp. 323, 519.

[7] A. Gorodetskaya: *Journal of Physical Chemistry* (U.S.S.R.), 1949, vol. 23, p. 71.

[8] B. Stuke: *Die Naturwissenschaften*, 1953, vol. 39, p. 325.

[9] J. Hadamard: *Comptes Rendus*, Academy of Science, Paris, 1911, vol. 152, p. 1735.

[10] W. Rybczynski: *Bull. Acad. Sci. Cracovie.*, 1911, vol. 1, p. 40.

[11] F. H. Garner: *Trans.*, Institute of Chemical Engineers, 1950, vol. 28, p. 88.

[12] M. P. O'Brien and J. E. Gosline: *Industrial and Engineering Chemistry*, 1935, vol. 27, p. 1436.

[13] C. A. Coulson: *Valence*, p. 298. Oxford University Press, London, 1952.

[14] M. Linton and K. L. Sutherland: Dynamic Surface Forces, Drop Circulation and Liquid-Liquid Mass Transfer. Second World Congress on Surface Chemistry.

[15] H. Schlichting: *Boundary Layer Theory*, McGraw-Hill Book Co. Inc., 1955.

[16] K. L. Sutherland: *Journal of Physical Chemistry*, 1948, vol. 52, p. 394.

[17] V. G. Levich: *Journal of Electro-Technical Physics* (USSR), 1949, vol. 19, no. 1.

[18] A. N. Frumkin and V. G. Levich: *Journal of Physical Chemistry* (USSR), 1947, vol. 21, p. 1183.

Discussion of this paper sent (2 copies) to AIME before July 31, 1958, will be published in MINING ENGINEERING.

Discussion

Geology of Toquepala, Peru

by Kenyon Richard and James H. Courtright

(MINING ENGINEERING, page 262, February 1958, AIME Trans., vol. 211)

L. H. Hart *(Chief Geologist, American Smelting & Refining Co.)*— Because of a widely recognized association between breccia pipes of one form or another and many important copper deposits, conditions under which breccia pipes develop have been of great scientific interest for many years. Since these phenomena first attracted attention, many theories have been advanced to explain their origin. This is not unexpected, since it is likely that they have been formed by and under a wide range of conditions. Moreover, the entire subject is confused by the fact that the term *breccia pipe* is applied to a wide variety of occurrences. To discuss any part of the subject intelligently, therefore, it is necessary to start with definitions of the terms used.

In their discussion of the Toquepala deposit, Richard and Courtright have carefully defined the terms they have used in their presentation of a very logical geological history of Toquepala breccias. This is a real contribution, as there is no reference in the literature known to the writer where the history of a series of breccia pipe epochs, confined essentially within one channelway, may be read with the degree of certainty that appears to be possible at Toquepala.

Although the following comments are intended primarily to emphasize points brought out in the article by Richard and Courtright, certan subsequent detailed mapping by Hollister and Houston[7] within the main central mineralized area of the Toquepala deposits not only supports most of Richard's and Courtright's conclusions but also contributes additional facts that strengthen and broaden the whole concept of the origin of the Toquepala breccia pipes.

In detailed mapping by Hollister and Houston,[7] the most significant feature disclosed is a well developed system of concentric fracturing in rocks peripheral to the main breccia pipe throughout an arc of 300°, interrupted only by the late dacite agglomerate in the north quadrant. Although Richard and Courtright noted that such fractures were developed in the southern and southeastern areas, continuity in the east and west quadrants is established by consistent orientation of the stronger set of fractures and joints. The existence of these structural weakness trends is emphasized by the emplacement of dike-like phenomena in and along members of this fracture system.

Richard and Courtright described one of these dikes in the southeast quadrant. They referred to it as a ring-dike, composed of dacite porphyry. This suggests an apparent structural control of at least a part of the dacite porphyry intrusion by features related to the Toquepala breccia pipe center. This raises a perplexing question, since the dacite porphyry intrusion had been presumed to antedate breccia pipe activity. However, if this ring-dike is related to the breccia pipe center, it may indicate that some part of the dacite porphyry intrusion advanced in a manner resulting in an intensely localized stress center, which produced the concentrically arranged fracture system. The ring-dike would then appear to be evidence strongly sug-

gesting that emplacement of the final stage of the dacite porphyry intrusion was influenced by these preexisting fractures and had accommodated itself to them. In this way, one prong of the dacite porphyry intrusion may have determined the position of the breccia pipe conduit and thereby prepared the way for the subsequent events that took place therein, including the introduction of mineralization. It is possible to visualize that this dacite porphyry prong may even have constituted the first pipe *break-through*, although no factual evidence supporting this has been observed. While the general hypothesis outlined above suggests that much of the fracturing of rocks peripheral to the pipe conduit was accomplished by stresses set up during the advance of the dacite porphyry, there is also much evidence that extensive fracturing and shattering of these rocks occurred later during the breccia injection period.

The sequence of events after the dacite porphyry intrusion is quite clearly defined and includes, first, a series of injections through the pipe-like conduit, which Richard and Courtright call *ore breccia*. They classify the second distinct breccia series *pebble breccia* and designate the final series *dacite agglomerate*. There is strong evidence that surges of activity of the first two classifications overlap and it is also likely that the dying phase of the pebble breccia epoch, postdated early dacite agglomerate. It is proposed that each of these series of events was intrusive in character. The history begins with the older classification, which Richard and Courtright call *ore breccia*, but which this writer prefers to subdivide into two groups: 1) pipe breccia and 2) peripheral shatter breccia. When these two components are carefully separated, as Hollister and Houston[7] have done in their detailed mapping, it is possible to establish the relationship of one to the other and thereby it is clear that the pipe breccia exhibits intrusive characteristics, because small outlying centers of this material are noted at considerable distances from the central pipe within the peripheral rocks. These small outliers are related to mappable structural weaknesses, often with dike-like characteristics conforming to the concentric fracture system. One of these, in the northeast quadrant, is about 60 meters distant from the main contact between the pipe breccia and the shatter breccia. This outlier is approximately 20 meters in width and traceable for a distance of about 120 meters, in a direction nearly parallel to the contact. It is also observed that close to the contact, material of pipe breccia type occurs in cracks and breaks within the intruded, shatter-brecciated rocks. However, the degree of penetration of this material diminishes rapidly away from the contact, and even near the contact it is surprisingly limited. This corresponds to a progressive decrease in the intensity of shattering and fracturing away from the pipe contact.

Many small inclusions and a few large inclusions or xenoliths of intruded rocks are observed within the pipe breccia center. In general, these appear to correspond to the adjacent, intruded rocks, and for this reason, at the surface where mapping is possible, they are largely dacite porphyry along the west border of the intrusive center and quartz diorite along the east side. This suggests only slight migration of entrapped inclusions, either upwards or downwards, but it seems certain that the isolated satellitic occurrences of pipe breccia could not have been emplaced by collapse, relaxational settling, or any means other than injection.

At some time, near the close of the activity of the pipe breccia injection, the first surge of the pebble breccia may have occurred, since there are a few cases described by Richard and Courtright where inclusions of pebble breccia are noted within their *ore breccia*. It is not entirely certain, in this writer's interpretation of this relationship, that the pebble breccia series became active before the close of the pipe breccia cycle. The occurrences of supposed inclusions in the *ore breccia* might be outliers from the pebble breccia center which have been injected—through cracks or other small openings by some media, at least simulating hydraulic or intrusive characteristics. All of these occur within a few meters of the pebble breccia contact.

Detailed mapping by Hollister and Houston[7] confirms Richard's and Courtright's conclusion that late pebble breccia dikes cut all of the rocks noted in the area, except latite dikes. One particular pebble-dike, which follows a pre-existing fault, is traceable for more than 200 meters and passes from east to west through quartz diorite, Quellaveco quartz porphyry, into pipe breccia. Also, there are countless inclusions and a few xenoliths of pipe breccia suspended within the pebble breccia center. There is one xenolith of dacite porphyry, with a diameter greater than 100 meters, within which a fairly large inclusion of pipe breccia (outlier) has been mapped. Thus the preponderance of evidence suggests that most, if not all of the pebble breccia, postdates the end of the pipe breccia cycle.

No comments herein apply to the dacite agglomerate, since subsequent studies have yielded no information suggesting any additions or modifications in the interpretations proposed by Richard and Courtright.

In summary, the writer proposes that some part of the dacite porphyry intrusion at Toquepala set up stresses that produced a system of concentrically oriented fractures, and then, in its final stage of advance, accommodated itself to zones of structural weakness so produced. Three series of later breccia injections traversed the Toquepala pipe or conduit, which, either by cause or effect, appears to have been an integral part of the concentric fracture system described.

Kenyon Richard and J. H. Courtright *(authors' reply)*—L. H. Hart's lucid amplification of certain aspects of Toquepala geology is much appreciated. Our comments on certain of his points follow.

The fractures which guided the emplacement of the dacite porphyry ring-dike are quite likely related to the breccia pipe center, but the possibility suggested by Hart that a dacite porphyry prong constituted the first pipe "break-through" is considered unlikely in view of field evidence that breccia formation began prior to the intrusion of the dacite porphyry, i.e., inclusions of ore breccia were found in dacite porphyry, as indicated in the writers' fourth paragraph under *Breccias* (page 264). To go further, inclusions of an earlier quartz-tourmaline breccia are found *within* ore breccia. Thus at least one, and possibly two, periods of brecciation preceded emplacement of dacite porphyry.

In the matter of ore and pebble breccia age relationships, there is little doubt as to the younger age of the main pebble breccia pipe and the dikes; however, evidence of an earlier intrusion of pebble breccia, which subsequently was incorporated in ore breccia, is clearly displayed in a road cut near the south margin of the main pebble breccia pipe. There, the ore breccia contains numerous inclusions of pebble breccia and is also cut by a dike of pebble breccia—demonstrating rather conclusively that at least two generations of pebble breccia are present. (The term *inclusions* is used strictly in a xenolithic sense, which precludes the alternative of small, attenuated intrusive bodies suggested in Hart's eight paragraph.)

The ore breccia can be subdivided into two units: 1) pipe breccia and 2) peripheral shatter breccia, as proposed by Hart. This distinction was recognized by the writers (third paragraph under *Breccias*) but was not mapped in detail.

As pit mining progresses there will be much better opportunities to observe age relationships. The writers anticipate that the brecciation-intrusion-mineralization sequences will be found to be even more complex than is presently recognized.

Reference

[7] V. F. Hollister and P. K. Houston, Geological Dept., American Smelting & Refining Co., November 1955.

SME BULLETIN BOARD

Reports of Your Technical Society

Newsletters . . .

Rock in the Box page 705

Coal News page 707

Don't forget these meetings . . .

Rocky Mountain in September
October AIME-ASME Solid Fuels
Mid-America in October
see page 702

Meet The Mid-America Conference Committee on page 706

For a report on education and the discussion of current problems which took place at the Annual Meeting in February, see page 713. The Education Symposium papers given at the meeting begin on page 669.

Coming Next Month

AIME, Society, and Divisional nominations for 1959 officers.

PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

Name of Prospective Member: ______________________

Address ______________________

____

____

Name of AIME Member: ______________________

Address ______________________

____

____

Change of Address and Personals Form

CHANGING YOUR ADDRESS? Don't forget to notify us six (6) weeks before you move, if possible, to insure uninterrupted receipt of your publications and correspondence. Please fill in the form below and send it to: J. F. Lynch, Asst. Treasurer AIME, 29 West 39th Street, New York 18, N. Y.

Name ______________________

Old Address ______________________

____

New Address ______________________

____

PERSONALS: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Former Company ______________________

Former Title ____________ **Length of Time There** ____________

New Company ______________________

New Title ____________ **Date of Change** ____________

Any recent activity that would be of interest to members:

____

____

SME Members Are Planning Now for Forthcoming Fall And

The conveniently located and amply appointed Chase-Park Plaza Hotels in St. Louis will be headquarters when mineral industry people gather in October for the Mid-American Minerals Conference.

St. Louis in October To Be Setting for Mid-America

Conference Plans Announced

The spacious and well appointed Chase-Park Plaza Hotels, centrally located in St. Louis, will be the setting for the Mid-America Minerals Conference, October 23 to 25.

The hard-working committee, directed by G. Donald Emigh, have been busy formulating plans and making preparations for this fall event. For an introduction to these busy people, turn to page 706.

On the technical program there will be papers of interest to members of the Society of Mining Engineers and The Metallurgical Society. On the first day of the meeting, October 23, there will be simultaneous morning sessions for geology, geophysics, and industrial minerals as well as a general session. Plans for the afternoon's program call for mining, including beneficiation, and extractive metallurgy sessions.

The October 24 technical program will include extractive metallurgy and coal sessions in the morning.

Feature on October 25 will be an Iron Symposium covering geology, mining, utilization, and economics, giving a broad range for those interested in this vital element.

The field trips on October 24 have been arranged so that there will be one of interest to each registrant. Those offered will be trips to a steel mill or smelter, the River King Mine of Peabody Coal Co., and the Indian Creek Mine and Mill of St. Joseph Lead Co.

The social side of the meeting is certainly not being neglected. Events on October 2 will be inaugurated by the welcoming luncheon, and the day's activities will be climaxed with a cocktail party. The following day there will be a minerals luncheon. The major social event will be the dinner-dance on October 24.

For an introduction to G. Donald Emigh and his Mid-America Minerals Conference Committee Chairmen, please turn to page 706.

AIME-ASME Joint Solid Fuels Meet To Be Held In Virginia in October

The annual AIME-ASME Joint Solid Fuels Conference will take place this year at the Hotel Chamberlin, Old Point Comfort, Va., October 9 and 10.

In addition to technical sessions, the committee is planning a field trip to nearby docking facilities, the main business of which is coal for export.

Arrangements for the meeting this year are being handled by ASME and E. E. Williams, vice president, Duke Power Co., Charlotte, N. C., is general chairman. AIME co-chairman is G. G. Ritchie, coal traffic manager-engineering, Chesapeake and Ohio Railway Co., Richmond, Va.

Other committee chairmen are: *finance*, Julian E. Tobey, president, Appalachian Coals Inc., Cincinnati; *hotel*, Sam C. Brown, Jr., Virginia Electric and Power Co. Yorktown, Va.; *registration*, J. C. French, National Advisory Committee for Aeronautics, Langley Field, Hampton, Va.; *publicity*, Carl S. Dennis, Chesapeake and Ohio Railway Co., Richmond, Va.; *technical details*, George Bradley, Hampton, Va.; *entertainment*, John Irvine, Newport News Shipbuilding & Dry Dock Co., Newport News, Va.; and *transportation*, C. C. Wagoner, Virginia Electric & Power Co., Yorktown, Va.

The program committee is under the chairmanship of J. R. Garvery, AIME, Bituminous Coal Research, Columbus, Ohio. L. P. Copian,

Hawaii Is Target for Post-San Francisco Travelers

Hawaii at any time of the year is inviting but especially in February. Plan now to enjoy the pleasures and relaxing atmosphere of this island paradise as part of the AIME post-Annual Meeting trip which takes off on Friday, Feb. 20, 1959, immediately following the San Francisco meeting.

Winter Meetings

ASME, Riley Stoker Corp., Worcester, Mass., is the reporting representative.

To reach Old Point Comfort, located at Fort Monroe, near Newport News and Norfolk, Va., there is C & O Railway service to Newport News and C & O Railway delivery service to the Hotel Chamberlain from the rail point. Airline service is available on Capital or National Airlines to Patrick Henry Airport, Newport News, or to Norfolk Municipal Airport in Norfolk. Bus or limousine facilities serve the hotel.

Universities Sponsor Symposia in the Fall

Among the list of forthcoming fall meetings of interest to members of the Society of Mining Engineers, are two symposia sponsored by the University of Minnesota and Missouri School of Mines and Metallurgy.

The annual Drilling Symposium of the University of Minnesota will be held in Duluth on October 2 to 4.

The fourth annual Symposium on Mining Research, under the sponsorship of the School of Mines and Metallurgy, University of Missouri, will be held at the school in Rolla, Mo., November 13 and 14.

Further details for both these symposia may be obtained by writing directly to the Universities concerned.

International Meetings Planned for September

A series of international meetings of interest to engineers, sponsored by the Engineers Joint Council Committee on International Relations, will be held in Canada and the United States during September 1958. The three meetings, and two study tours, are arranged in series to permit attendance at all events without conflict.

The *package* of meetings consists of: Fifth Convention of the Pan American Federation of Engineering Societies (UPADI), Montreal, September 3 to 6; Sectional Meeting of the World Power Conference, Montreal, September 7 to 11; Study Tour of St. Lawrence River Navigation and Power Projects, to Niagara Falls, to the Nuclear Power Station at Shippingport and to New York, September 11 to 14; and Sixth International Congress on Large Dams, Statler Hotel, New York, September 15 to 20.

Following the Large Dams Congress proper, a group of one-week-long study tours has been arranged. Participants have the option of visiting sections of the southeast, the midwest, or the northwest, depending upon which tour they choose.

NC-1 MINE CAR TRUCKS

NATIONAL CUSHIONING UNITS

every day, every year more and more mine cars and locomotives are equipped with

NATIONAL DEVICES

No matter whether you're considering the purchase of new mine cars or locomotives . . . or whether you're thinking of upgrading existing equipment—*now* is the time to investigate the advantages of National devices.

For every day cost-conscious operators everywhere are switching over to National devices because they know they get more out of their equipment investment per workshift . . . per day . . . per year.

AA-6732

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY

Established 1868 *Cleveland 6, Ohio*

WILLISON AUTOMATIC COUPLERS · RUBBER CUSHIONED UNITS · NACO STEEL LINKS and SWIVEL HITCHINGS · MINE AND INDUSTRIAL CAR TRUCKS · NACO STEEL WHEELS

CANADIAN SUBSIDIARY *National Malleable and Steel Castings Company of Canada, Ltd. · 128 Simcoe St. · Toronto 1, Ontario*

NACO STEEL WHEELS

WILLISON AUTOMATIC COUPLERS

ROCK IN THE BOX

Mining & Exploration Division

Procedure for Division Publications Outlined

The organization of the Publications Committees under the new By-laws of the Mining & Exploration Division has been completed. The Publications setup is shown in the chart below.

The Geophysical and Geochemistry Unit Committee Chairmen have decided to form joint committees for this year for program, publications, and membership and, as shown below, the Geochemistry and Geophysical Publications Chairmen are the same for these two units.

Papers submitted to AIME that come under the scope of M&E will be sent to the proper Unit Committee Publications Chairman for review. He, in turn, may send the paper to specialized readers who are experts on the particular subject covered.

On the proper forms supplied by SME the reader and Unit Committee Chairmen will make comments on recommendations to the Society concerning publication of the paper.

For example, a paper might be of general or current interest and be excellent magazine material, yet might not be of permanent technical interest and therefore not suited for publication in Transactions. The general publications policy will be guided by the Unit Chairmen and Vice Chairman, Publications, and prompt review of papers will be carried out under the proposed system. It is imperative that members of the various Publications Committees act promptly on material submitted to them to insure proper function of the Publications Committee.

D. DELICATE

H. J. SCHWELLENBACH

O. KINGMAN

G. R. ROGERS

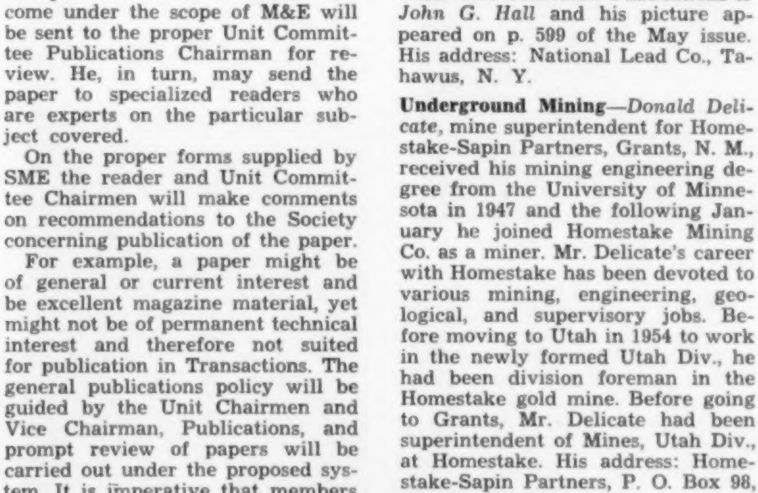
M&E Vice Chairman Publications is *John G. Hall* and his picture appeared on p. 599 of the May issue. His address: National Lead Co., Tahawus, N. Y.

Underground Mining—*Donald Delicate,* mine superintendent for Homestake-Sapin Partners, Grants, N. M., received his mining engineering degree from the University of Minnesota in 1947 and the following January he joined Homestake Mining Co. as a miner. Mr. Delicate's career with Homestake has been devoted to various mining, engineering, geological, and supervisory jobs. Before moving to Utah in 1954 to work in the newly formed Utah Div., he had been division foreman in the Homestake gold mine. Before going to Grants, Mr. Delicate had been superintendent of Mines, Utah Div., at Homestake. His address: Homestake-Sapin Partners, P. O. Box 98, Grants, N. M.

Open Pit—*Henry J. Schwellenbach,* production coordinator for New York Trap Rock Corp., is a native of the Upper Peninsula of Michigan and a graduate of Michigan College of Mining & Technology in 1938 with a B.S. Following graduation he worked for various gold mining companies in the Western U.S. and worked in research for Anaconda Copper Mining Co. before going to Chile where he spent three years in the production department of Andes Copper Mining Co. After service beginning in 1943 in the U. S. Navy aboard a destroyer in the Mediterranean theater, Mr. Schwellenbach joined Idarado Mining Co. in Ouray, Colo. He was associated with National Lead Co. and Warren Foundry and Pipe Co. before joining New York Trap Rock in 1955. His address: New York Trap Rock Corp., Old Mill Road, West Nyack, N. Y.

Geology—*Owen Kingman,* a native of Fort Collins, Colo., graduated

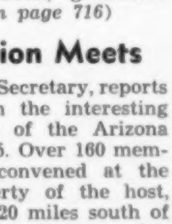
(*Continued on page 716*)



Arizona Section Meets

J. L. Carne, M&E's Secretary, reports to the Division on the interesting Open Pit meeting of the Arizona Section on April 25. Over 160 members and guests convened at the Pima mine, property of the host, Pima Mining Co., 20 miles south of Tucson. Those attending participated in a well guided tour of the mine in the morning before recess for a Mexican lunch. The afternoon technical session at the El Conquistador Hotel in Tucson was devoted to papers by R. V. Bamerio, Lynn Christian, and A. A. Friedman, whose subjects were, respectively, turbochargers on haulage trucks, primary blasting with prilled ammonium nitrate, and recent mining developments in East Africa. The day's events came to a relaxing climax with cocktails and dinner at the hotel. Members of M&E attending congratulate Pima Mining Co. for an excellent meeting.

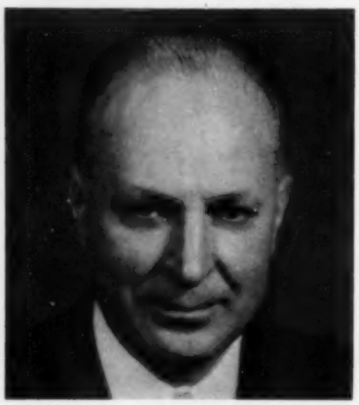
Rock in the Box Editor



Address news items to: John W. Chandler, American Metal Climax Inc., 61 Broadway, New York 6, New York.

Meet the Mid-America Minerals Conference Committee

The committee for the Mid-America Minerals Conference, to be held in St. Louis October 23 to 25, is busy formulating plans and making arrangements for this major fall event.

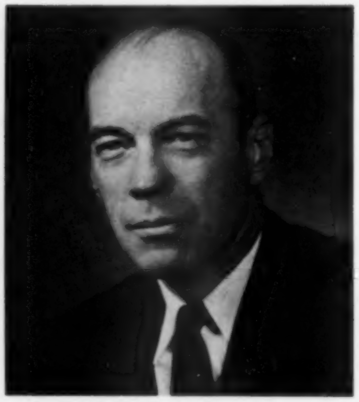


G. D. EMIGH

G. Donald Emigh, *General Chairman,* a native of Idaho, is a graduate of the University of Idaho and later earned M.S. and Ph.D. degrees from the University of Idaho and the University of Arizona. Now director of mining for Inorganic Chemicals Div. of Monsanto Chemical Co., Mr. Emigh is in charge of phosphate mining operations. Prior to joining the chemical concern, he had been associated with U. S. Vanadium Corp., a subsidiary of Union Carbide Corp. During his school years he was employed for five summers by USGS and immediately following graduation, spent some time with several small mining operations in the West. He is Central Regional Vice President of SME.

G. M. BELL

Gordon M. Bell, *Finances and Arrangements Chairman,* is a native of Liverpool, England, and senior research engineer for Aluminum Co. of America in their research laboratories, Alumina and Chemicals Div., East St. Louis, Ill. A graduate of the University of British Columbia in 1942 with a B.A.Sc. in metallurgical engineering, Mr. Bell was later an instructor and graduate student in mineral engineering at Massachusetts Institute of Technology, receiving an Sc.D. in 1953. His early professional experience was gained as engineer for Falconbridge Nickel Mines Ltd., physical metallurgist for Aluminum Co. of Canada, and assistant professor of metallurgy, University of British Columbia. He joined Alcoa in 1953 to start a program of beneficiation research. At present Mr. Bell is secretary-treasurer of the AIME St. Louis Section.



G. MONTGOMERY

Gill Montgomery, *Program Committee,* although born in Newburg, Mo., moved to Bartlesville, Okla., in 1920. Mr. Montgomery, who is vice president and general manager of Minerva Oil Co., Mining Div., graduated from Missouri School of Mines with an B.S. in mining with geology option, returning in 1953 for his E.M. degree. For six years after graduation, Mr. Montgomery was engaged in geophysics for Phillips Petroleum and ITIO Co., before joining Minerva as mining geologist at the time its mining division was started with a major fluorspar ore discovery in Hardin Country, Ill. No stranger to AIME affairs and meetings, Mr. Montgomery was most recently coordinator for the SME program at the 1958 AIME Annual meeting.

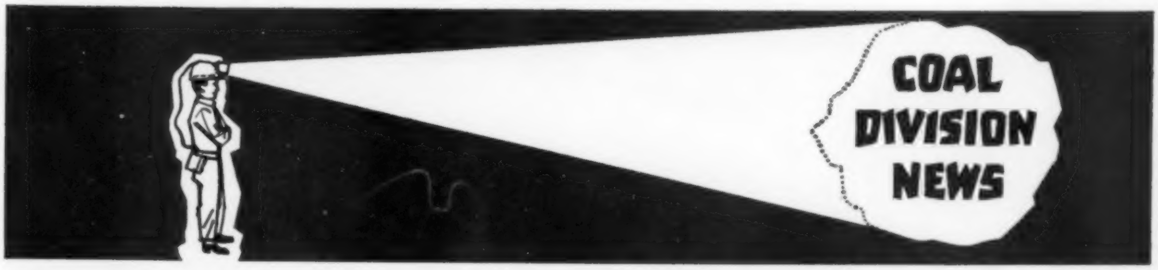
Joseph S. Quinn, *Social Arrangement and Student Interest Committee,* is sales representative for Allis-Chalmers Manufacturing Co. in the St. Louis district office and his major concerns are the mining, quarry, and cement industries in the area. A

J. S. QUINN

graduate of the Missouri School of Mines in 1949 with a B.S. in mining engineering, he served with the U. S. Navy for 2½ years. After receiving his degree, he joined the Allis-Chalmers' graduate training course and was later assigned to the company's Processing Machinery Dept. in West Allis, Wis. Particularly well suited for his Conference post, Mr. Quinn has been serving as chairman of the student activities committee of the AIME St. Louis Section.

MRS. N. L. SHEPARD

Mrs. Nat L. Shepard, *Ladies' Program Committee,* a native of Rosiclare, Ill., a fluorspar mining town in southern Illinois on the Ohio River, is a *veteran* in the mining industry. While employed by Aluminum Co. of America in the fluorspar district, she married Nat L. Shepard, a chemical engineer for Alcoa. She has two sons, one of whom is an undergraduate in mining engineering. An active member of WAAIME since 1945, Mrs. Shepard was chairman of the group in the St. Louis Section in 1956. Her hobbies are gardening, sewing, and bridge.



Coal Division program development this year is operating on three levels: Meetings *in the field* such as this month's get-together with the Central Appalachian Section, industry-level meetings such as the Joint Solid Fuels Conference in October, and next February, full-scale participation in the AIME annual meeting.

This multi-level and nationally coordinated technical program is another part of the Coal Division's unique role as the meeting ground for the administrator and the technical man, for the operator, scientist, and/or engineer.

Local and regional meetings provide an opportunity for the younger men to attend, for the exchange of information and problems characteristic of an area; industry level and national meetings provide an opportunity for concentration on technical specialties. But most important, these meetings provide for cross fertilization between area, between technical specialties, and between the younger and older men, both professionally and socially.

Division Officers

Division affairs are directed by Chairman J. W. Woomer; Chairman-Elect Raymond E. Salvati; Secretary-Treasurer George E. Keller; and an Executive Committee consisting of H. Eugene Mauck, Henry Rose, J. C. Gray, J. A. Hagy, C. J. Potter, W. L. Wearly, C. G. Ball, Edward G. Fox, and E. Minor Pace.

Committee Chairmen are: C. M. Donahoe, membership; W. E. Hess, program; G. R. Spindler, publications; Ernest M. Spokes, mining; Donald Dahlstrom, preparation; C. F. Hardy, utilization; Morris Cunningham, materials handling; Charles T. Holland, nominating; J. B. Morrow, joint solid fuels; Edward G. Fox, annual field meeting; Charles E. Lawall, scholarship selection; Hugo Nyquist, scholarship fund; and Elmer R. Kaiser (ASME), Percy Nicholls Award.

J. W. Woomer, a native of Philipsburg, Pa., holds B.S. and E.M. degrees from Pennsylvania State University. President-Elect of SME, he heads his own consulting firm, J. W. Woomer & Assoc. in Pittsburgh. Mr. Woomer's activities in the coal field have taken him all over the U. S. and to many parts of the world.

Raymond E. Salvati, a native of Monongah, W. Va., is president of Island Creek Coal Co. and Pond Creek Pocahontas Co., their subsidiary companies, and vice chairman of Island Creek Coal Sales Co. He is a graduate of West Virginia University and began his association with Island Creek in 1922.

George E. Keller, manager-coal evaluation for U. S. Steel Corp., was born in Illinois and graduated from the University of Illinois. Prior to joining U. S. Steel in 1954 he had been manager in Charleston, W. Va., and chemical director for Commercial Testing and Engineering Co.

H. E. Mauck, native of Danville, Ill., is general superintendent, Olga Coal Co., Coalwood, W. Va. A graduate of Pennsylvania State University, he began his professional career in coal in the engineering training program of Pittsburgh Coal Co.

Henry Charles Rose, an Ohioan by birth, is president of Pittsburgh Coal Co., a division of Consolidation Coal Co. A graduate of Ohio State University, he joined the Consolidation Coal concern in 1928 after brief periods with U. S. Gypsum Co. and American Rolling Mill Co.

James C. Gray is administrative vice president-raw materials of U. S. Steel Corp., Pittsburgh. A graduate of Pennsylvania State University and native of Elco, Pa., he began his career in coal with Hudson Coal Co. He became associated with U. S. Steel in 1937 in the Tennessee Coal & Iron Div.

James A. Hagy, manager of coal mines for Alabama Power Co., Birmingham, was born in Tazewell, Va., and is graduate of Virginia Polytechnic Inst. Prior to his present position, he had been associated with Jewell Ridge Coal Corp. and Crystal Black Coal & Coke Co., both in Virginia.

Charles J. Potter, born in Greenfield, Mo., and a graduate of Missouri School of Mines, is president of Rochester and Pittsburgh Coal Co., Indiana, Pa., which he joined in 1940. He has also served in the U. S. Dept. of the Interior in the Coal Div. and as deputy solid fuels and deputy coal mines administrator.

William L. Wearly was recently elected president of Joy Manufacturing Co., Pittsburgh. A veteran of 20 years, he had been vice president in charge of sales and executive vice president. A native of Warren, Ind., he graduated from Purdue University in 1937.

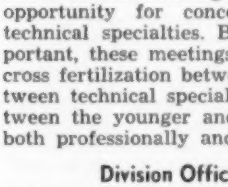
Clayton G. Ball, president of Paul Weir Co. Inc., is a geologist and graduate of Northwestern University with M.A. and Ph.D. degrees from Harvard University. Prior to joining Weir, he had been associated with Zeigler Coal & Coke Co., Illinois State Geological Survey, and Bell and Zoller Coal Co.

E. Minor Pace is general superintendent in Wheelwright, Ky., for Inland Steel Co. and a graduate of Virginia Polytechnic Inst. and West Virginia University. At Inland he has held the posts of mine engineer, superintendent of preparation plant, and mine superintendent.

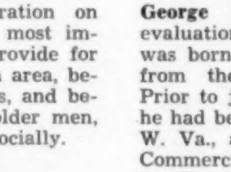
Coming Events

Among the *coming events* of interest to Coal Division members should be listed the next two Newsletters: July will be devoted to nominations for 1959 officers and August will present a resume of the Lexington, Ky., meeting in June.

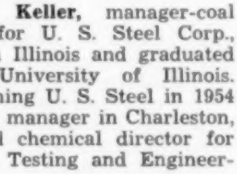
Don't forget the AIME-ASME Joint Solid Fuels Conference to be held in Old Point Comfort, Va., in October.



J. W. WOOMER



R. E. SALVATI



G. E. KELLER

Hard-working conference committeemen and Section officers were among those seated at the head table for the luncheon on Friday. Joseph L. Gillson, AIME Vice President, was the featured speaker and John Cameron Fox, SME Secretary was a guest. A. E. Weissenborn was general conference chairman. William D. Nesbeitt was chairman of general arrangements and his committee consisted of David E. Watson, printing; E. C. Stephens, financing; Richard N. Appling, Jr., publicity; and Frank N. Marr, liaison. Donald Ingvolstad was program chairman and Verne C. Fryklund, Jr., was vice chairman. They were assisted by M. C. Fetzer, physical metallurgy; John Cole, industrial minerals; J. J. Quinlan, geology; Joseph Gordon mining; Samuel Moyer, mineral beneficiation; Joseph Newton, extractive metallurgy; Earl Cook, education; Edward G. Oman, student participation; and Thomas E. Howard, field trips. Hamilton Owen was in charge of registration. Columbia Section, with E. C. Stephens, chairman, was host for the conference. Officers of the Section and Subsections are Rollin Farmin and Angus Y. Bethune, Coeur d'Alene; S. M. Barton and Harry W. Marsh, Snake River; and Carlos E. Milner, Jr., Columbia secretary-treasurer.

Minerals Men Gather in Pacific Northwest

The annual—and highly successful—Pacific Northwest Regional Conference was held in Spokane April 17 to 19, with the Columbia Section and its Subsections as hosts. Cooperating organizations for the conference were the AIME Oregon and North Pacific Sections, Mining Bureau of the Spokane Chamber of Commerce, and the Northwest Mining Assn., as well as mineral industry companies in the area.

After two days of full technical sessions and gay social events, the registrants took off on field trips to nearby areas. Two choices were offered—one to the new Gladding, McBean Co., brick plant at Mica, Wash., and the second to the Dawn Mining Co.'s mill at Ford, Wash., and Midnight Mine at Wellpinit, Wash.

A special feature of this year's program book was a series of illustrations dealing with mining and smelting as practiced in Germany in the 17th and 18th centuries. These prints were made available to the conference committee through the courtesy of the Northwest Mining Assn., The William M. Peschel Collection, and the College of Mines of the University of Idaho. The collection amassed by William M. Peschel is on permanent loan basis to the University of Idaho by Mrs. Annie L. Peschel and other heirs. Members in the Pacific Northwest region had a chance to view the prints and collection in December.

Principal Speakers

Speaker at the opening luncheon on Thursday at the Spokane City Club was T. S. Lovering of the U. S. Geological Survey, Denver. Dr. Lovering, who spoke on *Preparation for a Career in Earth Sciences*, is an advocate of starting basic science courses at the high school level, intermixed with a generous sprinkling of the humanities, particularly English. The development of an ability to speak and read English cannot be stressed too much, and foreign languages—Spanish, Russian, and French—will become more and more the essential tools for operator and explorer in the minerals field.

In discussing the courses an engineer would need in his own field, Dr. Lovering stressed his view that students in college and university courses should be taught those subjects they will use in professional life and those courses used in some areas as *weeding out* subjects should be omitted from the curriculum as nonessential.

The second major luncheon speaker was Joseph L. Gillson, AIME Vice President and chief geologist of E.I. du Pont de Nemours & Co., Wilmington, Del. Dr. Gillson, who spoke at the Friday luncheon at the Davenport Hotel, discussed the *Changes Brought About in Home and Industry by Development of Industrial Minerals*. Many of the industrial minerals we now take for granted were just names of obscure mineralogical curiosities in 1912. The industrial minerals mining industry product is currently valued at more

Mineral industry notables snapped before the buffet dinner include E. C. Stephens, Columbia Section chairman, Anaconda Co.; J. L. Gillson, AIME Vice President, du Pont de Nemours & Co.; J. C. Fox, Society of Mining Engineers; A. E. Weissenborn, Pacific Northwest Conference chairman, U. S. Geological Survey; and Karl Jasper, Northwest Mining Assn., Grandview Mines.

The ladies enjoyed the buffet dinner as much as did their husbands. Mrs. M. Pete Shrauger was the general convention chairman for the ladies and her co-chairman was Mrs. W. Randolph Green, who also headed the hostess committee. Other committeewomen were Mrs. Dana Smith, hospitality; Mrs. Calos E. Milner, Jr., coffee time; Mrs. Edward B. Olds, entertainment; Mrs. Eskil Anderson, decorations; Mrs. Samuel Moyer and Mrs. Karl Jasper, favors; Mrs. Edward G. Oman, publicity; and Mrs. Clifford Sherwin, door prizes.

than $3 billion (1957 figure). By 1965 it is estimated that the demand for industrial minerals will be so great that present productive capacity will be inadequate.

In relating this expansion of the industrial minerals field to the so-called *surplus* of young mining engineers now graduating, Dr. Gillson pointed out that we need to train young men to take care of future needs, and that any apparent oversupply of manpower is only temporary.

Technical Sessions

The opening session of the conference on Thursday was a general one on education of interest to all registrants. Among the speakers and their subjects were H. C. Mayer, Jr., *General Electric's Educational Assistance Programs;* Charles Sweetwood, *Cooperation Between Smaller Companies and the Universities;* L. J. Randall, *Cooperation Between the Mining Industry and Mining Schools;* G. S. Ortner, *Vacation Employment of Technical Students by Cominco;* J. P. Spielman, *Benefits to Technical Education from an On-Campus Research Institute;* and Harold W. Wessman, *Government Aid to Scientific and Technical Education.*

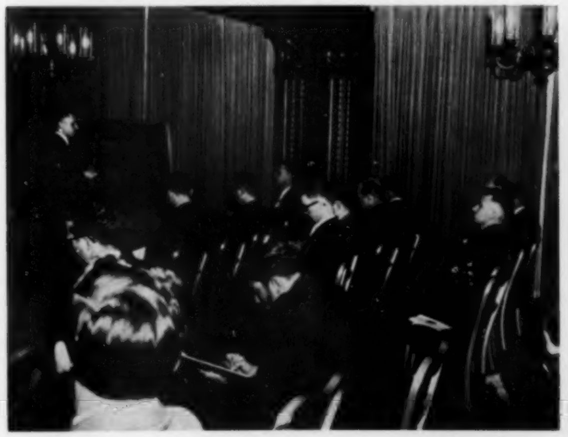
The remarks by each of the speakers led to lively discussion from the floor. Dean Earl F. Cook of the School of Mines, University of Idaho, led off with a statement of the general problem of producing more and better engineers and scientists. The next three speakers gave industry's view of the opportunities, through company programs and industry-wide cooperation with the mining schools. The smaller mining company, in particular, gives the young man an unusual opportunity for growth in the field and in experience. Cominco, a further example, has a program of vacation employment which offers advantages to both student and employer.

The last two speakers on the session touched upon separate phases of the scientific advancement problem. Dean Spielman elaborated upon the role of a research organization on campus. Dean Wessman outlined the various Government proposals for aid to science and technology. Two bills then before Congress, he felt, fell short of their purpose: assuring the intellectual preeminence of the U. S., particularly in science and technology.

The rest of the technical sessions during the meeting were divided into concurrent programs for fields of interest. There were four sessions for geologists, geochemists, and geophysicists, covering uranium geology, geochemical prospecting, the Coeur d'Alene area, and a general session. Papers on three of the sessions covered specific regional geologic problems and developments while papers on the prospecting session were general and touched upon the use of rubeanic acid in copper prospecting and general developments in geochemistry.

For minerals beneficiation and extractive metallurgy people there were two sessions. The first dealt with such materials and processes as phosphate rocks, flotation of chromite from olivine, maganese oxides, and autunitic ores. Interest over the past years in uranium was reflected in the second session. Ion exchange for recovery of vanadium from uranium leach liquors and pressure leaching in uranium leaching were two of the processes described. Also discussed was application of a shrouded mixer impeller for uranium solvent extraction.

(Continued on page 716)



The technical sessions covered a wide range of topics and were marked by audience participation via questions and discussion. At left a speaker poses a mathematical problem for his listeners while the speaker at the right makes a salient point in connection with his slide.

Third Annual Mining, Minerals, And

The mineral industries and the Dept. of the Interior was the subject discussed by Royce Hardy, assistant secretary of the department for mineral resources, at the technical session on Saturday.

Prospectors and miners from earth someday will be working on the moon and some of the other planets. That was the viewpoint of Sydney Chapman at the third annual Alaskan Mining, Minerals, and Petroleum Conference, sponsored by the AIME Alaska Section in connection with the AIME Southwest Alaska Section and the University of Alaska.

The meeting was held April 18 to 20 on the University of Alaska campus and Dr. Chapman spoke at the Public Banquet in Fairbanks, Alaska, which climaxed the meeting. He is president of the International Committee for the International Geophysical Year and his speech dealt largely with the accomplishments of the IGY. Peter Sandvik is chairman of the host section.

Speakers

Minerals industries personnel from all over Alaska and from several states attended the conference, and many distinguished persons besides Dr. Chapman participated in the various technical sessions. These included Roger V. Pierce, AIME Vice President and consulting engineer from Salt Lake City, and Royce Hardy, Assistant Secretary of the U. S. Dept. of Interior for Mineral Resources, Washington, D. C.

Mr. Pierce spoke on *The Growth of AIME* at the Friday banquet for which Mr. Sandvik and Earl H. Beistline, dean of the University of Alaska School of Mines, were comasters of ceremony. In his talk, Mr. Pierce emphasized that the mineral industries constitute the very base of the structure upon which America's technological development rests. He urged that the industries receive added incentives to enable them to perform their important functions. He also urged that mineral industries schools be given added incentives to attract and hold top students.

Mr. Hardy spoke on *The Mineral Industries and the Department of the Interior*. He explained the department's policies, and predicted that Alaska will enjoy greater returns from her mineral wealth, particularly if she achieves statehood, to which Frederick A. Seaton, Secretary of the Interior, is dedicated. Mr. Hardy also forecast increased oil activity in Alaska, and noted the presence of many petroleum officials at the conference.

Technical Sessions

Ernest N. Patty, president of the University of Alaska and former dean of the School of Mines, welcomed the various individuals and groups to the Conference at an April 18 luncheon in the Constitution Hall. James A. Williams, mining engineer for the Territorial Dept. of Mines, opened the technical sessions with an explanation of the *Problems and Economics of Mining in Alaska*. Second speaker was Paul T. Allsman, chief mining engineer for the U. S. Bureau of Mines, Washington, D. C. His subject was *Mining Research*.

Nalin R. Mukherjee spoke on *Present Status and the Future of Geochemical Prospecting* and predicted increased use of geochemical prospecting, particularly in Alaska where much of the land is covered with a heavy overburden of vegetation. Dr. Mukherjee is professor of chemistry, chemical engineering, and metallurgy at the University of Alaska.

WAAIME, with Mrs. Earl H. Beistline as chairman, provided coffee and other refreshments at the first technical session and at all subsequent intermissions.

The April 18 afternoon technical sessions also included Robert Lyman's presentation of a paper titled *The Operation of the Red Devil Mercury Mine*. He is manager of the Decoursey Mountain Mining Co., Red Devil, Alaska. He explained that reduction of Red Devil quicksilver ore

Attentive head table guests listen to Sydney Chapman, standing, who addressed the Saturday evening banquet at the conference. Dr. Chapman, who is president of the International Committee for the International Geophysical Year, discussed some of the IGY developments. Seated, left to right, are: Mrs. Ernest N. Patty; Dr. Patty, president of the University of Alaska; Mrs. Roger V. Pierce; Mr. Pierce, consulting engineer from Salt Lake City and AIME Vice President; James Crawford, master of ceremonies for this public banquet in Fairbanks; Mrs. Chapman; and Peter Sandvik, chairman of the AIME Alaska Section.

Petroleum Conference Held in Alaska

is complicated by the high percentage of stibnite in the ore, and that modification of a standard quicksilver plant, coupled with close temperature control, has partially solved the problem at his mine.

The April 18 technical sessions ended after a talk by Hugh Matheson on *Gold Mining Economics in Alaska*. He maintained that the Federal Government should substantially increase the price of gold. This action would put more prospectors in the field and would help a healthy gold economy. Matheson is manager and operator of the Chandalar Mining Co., Fairbanks, Alaska.

Student Prizes

Other activities at the April 18 banquet included introduction of guests, WAAIME officers, and Mining Society officers of the AIME Student Chapter at the University of Alaska. School of Mines scholarship recipients were introduced and they in turn introduced the scholarship donors.

AIME Awards were presented to graduating School of Mines students. The top award, a Brunton transit and case, went to LeVake Renshaw, mining engineering senior from Anchorage, as "the young man most likely to make a lasting contribution to mining in Alaska." Mr. Sandvik made the presentation.

Saturday Sessions

Mr. Hardy opened the April 19 technical sessions, followed by Ivan Bloch whose paper was titled *Economics of a Coal Mine Portal Power Plant for Interior Alaska*. Bloch is an electrical and industrial engineer, North Pacific Consultants. His paper was read by Nick Eidem, manager, Golden Valley Electric Assn., Fairbanks.

Feasibility of Nuclear Power in Alaska was the subject of Lt. Col. W. C. Gribble's paper. He is assistant district engineer, Corps of Engineers, U. S. Army, District, Alaska. Harold Moats presented *Hydropower—Alaska's Inexhaustible Resource*. Moats is chief of Civil Works, Corps of Engineers, U. S. Army, Elmendorf AFB, Alaska.

William Mendenhall, assistant professor of civil engineering at the University of Alaska, ended the April 19 morning technical sessions by reading a paper titled *Engineers Ain't Boobs*. Author is Elbert F. Rice, acting head of the Civil Engineering Dept.

Petroleum

The April 19 afternoon technical sessions dealt largely with oil, and more attention this year was paid to this field than at past conferences. Jack Crooker opened the sessions with a talk on *Careers in Petroleum Production*. He is production manager, Standard Oil Co., Anchorage.

Alaskans and others attending the conference received a comprehensive view of *Petroleum Exploration in Alaska, 1957* in the presentation by Charles E. Kirschner, district geologist for Alaska, Standard Oil Co. of California, Seattle.

Humble Oil Co.'s Operation In Alaska was presented by Joseph H. Homer, exploration manager for the company, with offices at Anchorage. The conference applauded the film which showed the firm's drilling operations on the Alaska Peninsula.

Conference-go'ers learned about the future growth of the petroleum industry and its impact on local commerce and industry from a paper by J. W. Dalton, staff consultant of the Resources Development Committee, Anchorage, Alaska. Dean Beistline summarized the paper. Two other important aspects of the entire petroleum industry were presented by Charles Barnes, consultant from Anchorage, and Ted C. Mathews, consulting engineer and president of Exploration Services, Fairbanks, Alaska. Barnes explained land problems and leasing and Mathews covered Alaska logistics.

Roger V. Pierce, AIME Vice President, spoke at the banquet on Friday at the University of Alaska. His topic was the growth of AIME.

Peter Sandvik, president of the AIME Alaska Section, stated that in his opinion the speakers mentioned and others who participated had covered areas of particular interest to Alaskans who have within their territory (more than twice the size of Texas) a tremendous mineral potential which will in time play a far more important role than it has in the past.

The concluding day, April 20, of the conference was devoted to field trips in the interior Alaskan area.

Part of the Friday banquet ceremonies included presentation of AIME awards to seniors at the University of Alaska School of Mines. Here LeVake Renshaw, mining engineering senior from Anchorage, receives a Brunton transit from Peter Sandvik, AIME Alaska Section chairman.

AIME OFFICERS:

PRESIDENT—AUGUSTUS B. KINZEL
PAST-PRESIDENT—GROVER J. HOLT
PRESIDENT-ELECT—HOWARD C. PYLE
VICE PRESIDENTS—E. C. BABSON, L. E. ELKINS, J. L. GILLSON, J. C. KINNEAR, JR., R. V. PIERCE, A. W. THORNTON
TREASURER—C. R. DODSON
SECRETARY—ERNEST KIRKENDALL

AIME STAFF:

ASS'T. SECRETARIES—J. B. ALFORD, H. N. APPLETON, J. C. FOX, R. W. SHEARMAN
ASS'T. TREASURER—JOHN LYNCH
FIELD SECRETARY & ASS'T SECY.—R. E. O'BRIEN, 707 NEWHOUSE BLDG., SALT LAKE CITY 1, UTAH

AIME NEWS

AGI Career Booklet Is Government Distributed

The American Geological Inst.'s career booklet is now being distributed by the Government. The President's Committee on Scientists and Engineers, as a part of its local action program, has assembled a guidance kit to aid in the counseling of high school students on careers in science and engineering.

This kit includes the new AGI career booklet *Shall I Study Geological Sciences?* Also included is the recent U. S. Dept. of Labor Bulletin 1215-4 *Employment Outlook in the Physical & Earth Sciences*, available separately from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 20¢.

AIChE Joins UET; New Center Plans Progress

Among the steps leading to the completion of the new United Engineering Center was inclusion of AIChE in United Engineering Trustees Inc. with the Four Founder Societies—AIME, ASME, ASCE and AIEE—the original founders. AIChE was formally inducted into UET in May after approval of admission was given by the last of the Four Founder Societies.

Coincident with the admission of the chemical engineers was the announcement of the leadership of the Greater New York Business Campaign for funds for the new United Engineering Center. Mayor Robert F. Wagner will serve as honorary chairman and William H. Byrne, president of Byrne Assoc. Inc. and ASME regional vice president, will serve as general chairman. At a May 2 luncheon at the Waldorf-Astoria in New York, Mr. Byrne announced plans for the new Center to about 150 New York business and industry leaders.

The new United Engineering Center will be erected on United Nations Plaza (First Ave.) between 47th and 48th Sts. The site has been purchased and clearance is expected to begin later this year. Target date for completion of the building is 1960.

EJC Member Societies

American Inst. of Industrial Engineers recently became a constituent member of Engineers Joint Council, bringing the total of this class of membership in EJC to 11.

At its April meeting the board of directors of EJC accepted the Louisiana Engineering Soc. as an affiliate member. In late 1957 the Western Soc. of Engineers and the Engineering Socs. of New England became affiliate members.

The roster of EJC now includes 11 constituent society members; two associate societies, and four affiliate societies, a total of 17 members.

An EJC Policy Report On Employe Conditions

Engineers Joint Council's policy with respect to employment conditions of engineers in government employ became established at the April meeting of EJC board of directors, with its acceptance of the recommendations of the EJC Committee on Employment Conditions.

Substantially supporting the findings and recommendations of the Defense Advisory Committee on Professional and Technical Compensation of the Dept. of Defense (Cordiner report) to improve the status of engineers in government service, EJC has recommended implementation of that committee's findings by legislation which would accomplish the following:

1) Establish a commission to study and revise the present compensation system for professional, technical, and managerial employes of the Federal Government to provide for modern flexible system of compensation and improved professional climate which will be responsive to the changing needs of the Federal Government and provide an inducement for qualified persons to enter and remain in the employ of the Federal Government.

2) Amend the compensation schedule of the Classification Act of 1949 to provide a higher top Classification Act salary and to provide for various intermediate grades as close as practicable to comparable industry scales without compression in the upper grades and with significant differentials between grades.

3) EJC also recommends increase of pay for engineers in the uniformed services. Because of the seriousness of recruiting and retaining engineering and scientist personnel, it is strongly urged that specific consideration in the form of incentive pay be given to this group.

Shown at the ceremonies connected with the signing of the Founders' Agreements in May when AIChE became a member of UET are, left to right, seated: David W. R. Morgan, past-president of ASME who represented ASME president James N. Landis; Augustus B. Kinzel, AIME president; Walter J. Barrett, president of AIEE and UET president; George E. Holbrook, AIChE president; and Louis R. Howson, ASCE president. Left to right, standing, are the Society secretaries; O. B. Schier, II, ASME; Ernest O. Kirkendall, AIME; Steven W. Marras, UET; F. J. Van Antwerpen, AIChE; and William H. Wisely, ASCE.

SME Educator Groups Discuss Problems

In addition to the sessions of the Council of Education of AIME held on Sunday, February 16, during the Annual Meeting, two other meetings of interest to educators were held. An informal group met for breakfast on Monday, February 17, and the SME Education Committee met the same morning. The papers given on the Society of Mining Engineers' part of the Sunday education sessions begin on p. 669 of this issue. Reports of the AIME Council of Education sessions at the Annual Meeting were given on p. 613 of the May issue of MINING ENGINEERING.

Among those participating in the informal discussion at breakfast were incoming SME President S. D. Michaelson, D. H. Yardley, L. J. Parkinson, G. B. Clark, J. D. Forrester, L. E. Shaffer, H. Hartman, and R. D. Parks. The breakfast was arranged to enable those interested in education in the minerals industry field to become better acquainted.

Among the topics explored at breakfast were the need for up-to-date textbooks in mining engineering; the possibility of a laboratory manual for mine air conditioning, mine plant, and rock mechanics experiments; a standardized procedure for recording statistical data on mining engineering students in training; exchange lecture programs for minerals engineering schools; the ECPD program for curriculum standardization and school inspection; and inadequacies of current curricula in mining engineering.

In regard to textbooks, proposals for revising Lewis' *Elements of Mining* and Peele's Handbook were explored. Actually, no new mining engineering textbooks have been printed in the U. S. in the past ten years.

SME Education Committee

The following actions were taken at the SME Education Committee meeting:

Engineers' Council for Professional Development—The chairman of the committee was authorized to send a questionnaire to the schools of the various engineering areas concerned, requesting names of individuals from fields of education and industry who would be interested in serving as representatives of AIME to ECPD and that a biographical sketch of the individual be included with the recommendation. The recommendations are to be channeled through the chairman. The various mineral engineering categories concerned were defined. Civil Service personnel are not eligible for ECPD committees. An individual in education must be of the rank of associate professor to be eligible.

SME Preprints—The Secretary of SME was authorized to circularize the chairmen of departments in mining engineering schools in order to ascertain whether they would like to receive a complete set of SME preprints. Sets of preprints are to be provided to those schools who indicate a desire for them and who indicate a willingness to defray shipping expenses.

Directory—The Education Committee recommended to the SME Board of Directors that approximately $300 from the 1958 budget be made available for the financing of a directory of mineral engineering educators. Dr. Howard Hartman of Pennsylvania State University has agreed to compile such a directory.

Subcommittee—The chairman of the committee was given the responsibility of appointing necessary ad hoc committees.

Bylaws—The committee felt that a set of bylaws was unnecessary at the present time.

Careers Booklet—The committee recommended to the AIME Board of Directors that the information and career booklet on earth sciences be revised and promoted.

Around the Sections

• The **Reno Subsection,** Nevada Section, held its monthly meeting at the Mapes Hotel on March 14. Guest speaker Adrian Keith Long of the U.S. Bureau of Reclamation outlined the Washoe Project and discussed the effect this reclamation project will have on the economy of western Nevada.

• Elmer W. Pehrson, chief, Div. of Foreign Activities of the U. S. Bureau of Mines, was the featured speaker at the March 27 dinner meeting of the **Mineral Industries Group,** Pittsburgh Section, held at the Gateway Plaza Restaurant. Mr. Pehrson, who recently visited 26 countries in the East and Middle East, studying various aspects of the mineral industries of Asia, gave his observations on conditions in this critical part of the world. His talk was illustrated with Kodachrome slides.

• L. L. Newman, assistant chief coal technologist, U. S. Bureau of Mines, was the guest speaker at the March 20 meeting of the **Utah Section,** held at the Newhouse Hotel, Salt Lake City. His subject—*Mechanization of the Soviet Peat Industry.*

• The **MBD Subsection** of the Colorado Section, will hold its annual meeting at the Broadmoor Hotel, Colorado Springs, on May 24. A technical and business meeting will be held in the afternoon and a banquet and dance in the evening. The program for the technical meeting includes papers on uranium metallurgy at Maybell, Colo., potash metallurgy at Carlsbad, N.M., and the technology of the combined fluosolids-hydrometallurgical plant at Bagdad, Ariz. At the business session one of the subjects for discussion will be a suggestion that excess funds accumulated in the MBD treasury be contributed to the Student Loan Fund at the Colorado School of Mines.

• The **Arizona Section** announces that the 1958 spring meetings of the various Divisions have been or will be held as follows: Geology, Ray, Ariz., April 12; Underground Mining, Cananea, Sonora, Mexico, June 14; Open Pit Mining, Pima Mine, south of Tucson, April 25; Smelting, Miami, Ariz., May 3; Ore Dressing, San Manuel, Ariz., May 17.

The Arizona Section has announced election of the following Subsection officers for 1958: *Ajo*—Warren D. Caton, chairman; Robert E. West, vice chairman; and Alex H. Lyons, secretary-treasurer. *Bisbee-Douglas*—H. D. Clark, chairman; G. A. Van Etten, vice chairman; J. H. Ladd, secretary-treasurer; and J. S. Crowley, membership chairman. *Morenci*—Felix Berra, chairman; C. C. Riley, program and vice chairman; Charles Sorvisto, secretary-treasurer; and A. L. Alexander, nominating and membership chairman. *Yavapai*—Arthur R. Still, chairman; Fred Gibbs, vice chairman; and A. W. Jeffers, secretary-treasurer.

• The **Adirondack Section's** new officers for 1958 are: Malcolm V. Lowry, chairman; Charles F. Dievendorf, vice chairman; Severn P. Brown, secretary-treasurer; Franklin L. Beggs, program chairman; Charles R. Barton, Jr., membership chairman; and George E. Erdman, student affairs chairman. Program Chairman Beggs' committee members are Brower Dellinger and Arthur F. Peterson, Jr.

• The **St. Louis Section** held a meeting at Urbana, Ill., on April 11 that featured an afternoon tour and dinner in the evening. The facilities of the University of Illinois College of Engineering and the Illinois Geological Survey were covered during the tour. Hubert E. Risser, mineral economist, Illinois Geological Survey, spoke at the dinner, which was held in the Garden Room of the Hotel Urbana-Lincoln. Dr. Risser's subject was *Metallurgical Coke from Illinois Coal.*

• Byron T. Berge was elected chairman of the **Eastern Nevada Subsection** of the Nevada Section at a dinner meeting held at the Hotel Nevada on March 28. Mr. Berge will complete the unexpired term of William Wood, who has moved out of the district. Guests at the meeting were a party of geology students from the California Institute of Technology, who have been touring the area in connection with their studies. They are under the direction of James A. Noble of the Institute's Geology Dept. Dr. Noble gave a talk on mineral exploration in southeastern Alaska.

• The regular Tuesday luncheon meeting of the Colorado Engineering Council, under the auspices of the **Colorado Section,** was held at Daniels and Fisher dining room, Salt Lake City, on March 4. Jack Roeschlaub of Stearns-Roger Manufacturing Co. spoke on the uranium mill at Mexican Hat, Utah, and illustrated his talk with colored slides.

The dinner meeting of the **Colorado Section** was held on March 20 at the University Club, Denver. Feature of the meeting was a panel discussion on various phases of flotation. Leland Logue, Denver Equipment Co., acted as moderator, and the panel members included William Reck, Western Machinery Co.; Fred Hoff, American Metal Climax Inc.; Edwin Crabtree, Colorado School of Mines Research Inst.; O. W. Walvoord; Charles Beech, Stearns-Roger Manufacturing Co.; and John D. Vincent, American Smelting & Refining Co.

• The **Tri-State Section** elected the following directors for 1958: Andrew V. Bailey, Joseph B. Elisondo, Miles B. Landis, Sim S. Clarke, John J. Inman, Paul R. Hamilton, A. Paul Thompson, and Clinton C. Knox. At their first meeting on January 29, the 1958 Section officers were appointed as follows: Clinton C. Knox, chairman; Andrew V. Bailey, vice chairman; and Hugh Wright, secretary-treasurer. The new Section chairman has appointed committees as follows: Miles B. Landis, chairman, *Program Committee.* Mr. Landis is also leader of the *Kansas Group,* of the Program Committee, which includes Sim S. Clarke and J. C. Stipe. Lawrence E. Gordon is leader of the *Oklahoma Group,* which includes Glenn Scott and Douglas C. Brockie. Whitson J. Kirk is leader of the *Missouri Group,* which includes Philip L. Jones and Donald J. Doan. Other officers are: Claude O. Dale, chairman, *Membership Committee;* George Schaefer and Robert E. Illidge, *Tri-State Section;* Richard C. Lundin, membership chairman, *Soc. of Mining Engineers Mining and Exploration Division.*

• A joint dinner meeting of the **Mining and Minerals Beneficiation Subsections** of the Upper Peninsula Section was held on March 28 at the White Pine Inn, White Pine, Mich. Principal order of business was a paper on *Cyclones as Used at the White Pine Mill* by Virgil Lessels. In addition, Glenn Bowie of the Dept. of Mining Engineering at Michigan College of Mining & Technology conducted a discussion on what the min-

ing engineer should study to bring about advances in the mineral industries.

• O. J. Seeds, manager of the Alloy Dept., Cerro de Pasco Sales Corp., was the speaker at the dinner meeting of the **Washington, D. C., Section**, held on April 1 at the Cosmos Club. Mr. Seeds' discussion of the latest developments in industrial and other applications of bismuth alloys was accompanied by slides and a demonstration of the slush casting method for making molds.

• The **Lehigh Valley Section** held its spring dinner meeting on March 21 at the Hotel Bethlehem, Bethlehem, Pa. F. R. Morral, Battelle Memorial Institute, Columbus, Ohio, was the principal speaker. Dr. Morral accompanied his discussion on *Cobalt and Its Alloys* with a color movie on cobalt production in the Belgian Congo.

• Attendance records were broken at the spring meeting of the **Mining Geology Division** of the Arizona Section, held at Ray, Ariz., on April 12. Host for the meeting, which was attended by 97 members, was the Ray Mines Div., Kennecott Copper Corp. The day-long event included a business meeting, at which two technical papers were presented; the showing of a film; a tour; and a cocktail hour and Mexican dinner at the Club Royal, Ray.

At the business meeting, Chairman Jacques Wertz, a geologist with Bear Creek Mining Co., spoke on *The Geology of the Ray Ore Body*, and illustrated his talk with visual aids. The second paper was a discussion by Nels Petersen, USGS, Globe, Ariz., on the comparative geology between the Ray orebody and adjacent mineral areas. In the afternoon a Ray Mines Div. film, *Four Days, the Ore to Copper Cycle*, was shown. It was followed by a field trip into the Ray pit.

• The monthly meeting of the **Ajo Subsection** was held on April 10. High school juniors and seniors interested in studying engineering at college were guests at the meeting, and Dean Forrester, College of Mines, University of Arizona, was the speaker.

• The **Mining Subsection** of the Minnesota Section held a joint meeting with the Lake Superior Geology Club on March 26 at Chisholm, Minn. William M. Fiedler, chief geologist, Jones & Laughlin Steel Corp., gave his personal observations on the steel industry of Poland. Mr. Fiedler was a member of a group chosen by the U. S. State Department to tour Poland in September 1957 and view that country's steel industry.

The following 1958 Subsection officers were elected at the meeting: chairman, George Pell, Hibbing; vice chairman, Rudolph Ekar, Chisholm; and secretary-treasurer, E. R. Tyler, Keewatin.

ENGINEER*

"EJC's Report on What's Happening in Engineering"

*A Periodic Newsletter from Engineers Joint Council • 29 W. 39th Street, New York 18, N.Y.

EJC Regional (Chicago) Meeting, May 19

Next Decade in Engineering—Important midwest symposium at Sherman Hotel, hosted by Western Soc. of Engineers, considered survey of the engineering profession (Morris D. Hooven, president, Engineers Council for Professional Development), education and manpower (F. C. Lindvall, president, ASEE and chairman of engineering, California Institute of Technology), applied and basic research (Clyde Williams, former chief of Battelle Memorial Institute) and government in science and engineering (Eglehardt A. Eckhardt). Walter McNair, vice president, Bell Telephone Laboratories, was the luncheon speaker.

Rights of Engineers

The right of an engineer to bar the Atomic Energy Commission from disclosing previously secret data on heavy water process until his patent and other rights are adequately protected, is being considered by the U. S. Court of Appeals, at the request of the Supreme Court. This resulted from an appeal over the original ruling of the lower Court that the U. S. Agency could not be sued without its consent and therefore the Court did not have jurisdiction. The case concerns a member of AIChE who sought the support of the Institute. Because the problem is basic to all engineers of the country whose inventions are used by the U. S. under classification, AIChE referred the matter to EJC for joint action on behalf of the profession. EJC filed a *friend of the court* brief requesting the Supreme Court to review the case and rule on the matter of jurisdiction. It, in general, supported the engineer's appeal, which stated "in these days, when scientists and engineers are urgently needed in the race for national survival, it is imperative that their rights be respected and their incentives strengthened through such respect. These considerations and the principles concerned involve basic guarantees intended to be accorded by our form of government."

EJC Inc.

The State of New York has granted Engineers Joint Council the right to incorporate. The reorganization is now on paper and awaits the affirmative vote of two thirds of EJC constituent member societies.

FYI for the Future

From statement of G. E. Arnold, chairman, EMC; F. C. Lindwall, president, ASEE; and R. A. Morgen, director of Purdue Research Foundation, before Senate Committee on Labor and Public Welfare, chaired by Sen. Lister Hill (Alabama): By 1967 undergraduate engineering up 66 pct to 515,000; masters up 93 pct to 44,000; doctorates up 115 pct to 6,500. Number teachers in engineering is deteriorating. This paramount problem inasmuch as 90 pct of engineering graduates go to industry, only 10 pct to universities. Statement outlined problems of scholarships, economics of sacrifices for teaching careers. Impact of presentation according to Senator Hill "strong and excellent, fine and compelling testimony."

1958 Nuclear Congress

Cooperation by 29 major engineering and scientific groups in the nuclear energy field marked the 1958 Congress. Major components dovetailed included Nuclear Engineering and Science Conference (1800 registrants), NICB-AIF Atomic Energy in Industry Conference (more than 500), AIF Atomfair (5500 high school attendees among several thousand adults), and Hot Laboratories Conference. More than a dozen foreign countries represented. Vice President Richard M. Nixon, principal speaker at All-Congress dinner. Preprints of 1958 Conference technical papers at 50¢ on sale at AIChE, 25 W. 45th St., New York 17, N. Y. 1959 Congress scheduled for Cleveland, April 5-10, EJC coordinating ASME managing.

Emphasize Engineering

Pursuant to ASME executive committee resolution that the President is over-emphasizing pure science vs engineering, EJC has authorized its president to "communicate with President Eisenhower on the necessity of recognizing engineers in the application of science and the development of sciences."

Rock in the Box

(*Continued from page 705*)

from Colorado School of Mines in 1942 as a geological engineer. Prior to joining Tennessee Copper Co. he worked for New Jersey Zinc Co., Gilman, Colo., as engineer and geologist. Leaving his native state in 1947 when he became geologist for Tennessee Copper in Ducktown, Tenn., Mr. Kingman assumed the duties of chief geologist for the company in 1953. He joined AIME as a Student Associate and has been active in Local Section affairs. His address: Tennesee Copper Co., Box 366, Ducktown, Tenn.

Geophysics and Geochemistry—*George R. Rogers*, senior geophysicist for Bear Creek Mining Co., was born in Keokuk, Iowa, and attended Colorado School of Mines. Taking time out for a tour of duty with the U. S. Navy, Mr. Rogers returned to school for a geological engineering degree with a geophysics option in 1948. Pursuing a career in mining geophysics, he joined Phelps Dodge Corp. in 1948. Mr. Rogers became associated with Bear Creek in 1953 and is presently operating from the company's Denver office. His address: Geophysics Div., Bear Creek Mining Co., 516 Acoma St., Denver 4, Colo.

Pacific Northwest

(*Continued from page 709*)

The miners started their session with an Atlas Powder Co. film. Discussion of various problems included haulage roads, air-operated clamshell for sinking small shafts, shaft sinking and development under hot water, calculations for limiting grade, and operations at the Clayton silver mine in Idaho.

Following the talk by Dr. Gillson at luncheon, the industrial minerals men retired to delve further into topics with a regional flavor. The leadoff speaker touched upon industrial minerals in the Northwest and those following him on the program spoke about lime, heavy clay products, and fluorspar in the area.

For the physical metallurgists attending the meeting there were two sessions. The first covered a diversified group of subjects: effect of metal quality on the mechanical properties of aluminum plate, fatigue hardening of copper, and strain cycling fatigue in metals. This session closed with the showing of a film on depositing stellite with the oxyacetylene flame. The second session was devoted to some of the *popular* metals when speakers covered heat treatments of binary alloys of titanium and nickel alloys, hot hardness testing of aluminum and magnesium alloys, and current research on cobalt and its alloys.

Ladies Events

A full schedule of events was held for the ladies attending the conference. Each day there was an open house coffee time at the Davenport Hotel. Ladies were welcomed at the opening luncheon and buffet dinner on Friday. A special luncheon with an Hawaiian theme was planned for the ladies on Friday at the Spokane Club. The program included entertainment, favors, and door prizes. For those who wished, arrangements were made for cards after lunch.

Personals

Harmon E. Keyes, consulting chemical and metallurgical engineer with the firm of Harmon E. Keyes and Assoc., Phoenix, Ariz., is now at the Rosita property of La Luz Mines Limited, a subsidiary of Ventures Ltd. of Toronto. For the past year he has been engaged in the design of an autoxidation acid plant to be operated in conjunction with copper leaching at this property. For the next few months he will be in charge of erection and start-up of this plant.

Two new appointments in Norfolk, Va., have been announced by Eastern Gas and Fuel Assoc. **J. Baldwin Smith** has been named resident manager in the Virginia city. **Thorburn Graham** has been appointed Norfolk district sales manager. Both men are long-time employes of Eastern.

J. WICKSTROM

A. N. WEEKS

John Wickstrom has been appointed mining representative for the Sales Development Div., Caterpillar Tractor Co., Peoria, Ill. He joined the Sales Training Div. of Caterpillar in 1957.

J. P. Cullen has been named manager of clamshell bucket sales for the Equipment Div. of Blaw-Knox Co., Pittsburgh. He had been west coast manager for the company since 1951 with offices in San Francisco.

A. E. Williams, general sales manager of Robinson Clay Products Co., Akron, Ohio, has been elected to the board of directors. Well known in the clay industry, Mr. Williams has been associated with Robinson Clay since 1916.

A. N. Weeks, director of production, has been elected vice president in charge of production for Bemis Brothers Bag Co., St. Louis. Mr. Weeks, who joined Bemis in 1919, became director of production in 1957 when he succeeded **A. H. Clarke** upon the latter's retirement.

John H. Mathis, vice president and secretary of Lone Star Cement Corp., was recently elected a director of Inspiration Consolidated Copper Co. Mr. Mathis fills the vacancy caused by the resignation of **Charles S. Sargent,** a general partner of Hornblower & Weeks.

Olaf P. Jenkins has retired as state mineralogist and chief of the Div. of Mines, State of California, after nearly 29 years of continuous service with the division. In addition to his duties for California he was also an associate professor of economic geology at Washington State College and carried on consulting work in economic geology. The California State Personnel Board has announced that a successor is being sought, and that this man will be responsible for development of administrative policy, planning, and organization of division activities and for directing the staff engaged in geologic and commodity surveys, mining engineering, mineral economics, and technical information service. The vacancy will be filled by selection from a list of eligible candidates established by a nationwide, open, nonpromotional examination to be held July 19, and to be given in such places in California and other states as the number of applicants warrant and conditions permit. Applications for the examination will be accepted through June 20, 1958, at the State Personnel Board, Engineering Recruitment, 801 Capitol Ave., Sacramento, Calif.

Earl A. Bradley is now general manager of Ashland Div. operations for National Mine Service Co. Mr. Bradley, who will make his headquarters in Ashland, Ky., previously was manager of shuttle car products and mining trucks for Joy Manufacturing Co.

J. A. PERHAM

J. H. LAVERY

J. Allan Perham, formerly sales director at Atlas Copco headquarters in Sweden, has been made director of the Atlas Copco companies in the United States.

Augustus C. Long, chairman of the board of directors and chief executive officer of The Texas Co., has been elected a member of the board of directors of Freeport Sulphur Co.

Frank A. Carragher has been named southeastern sales representative for the Arizona Chemical Co. and will cover the states of Alabama, Florida, Georgia, Mississippi, South Carolina and Tennessee. **Wendell C. Otis** becomes sales representative of the region covering upper New York state and the New England states.

Joseph H. Lavery has been named South Carolina sales representative for the Carolina Solite Corp., manufacturer of Solite lightweight aggregate. Mr. Lavery, who will make his headquarters in the Charlotte, N. C., office of the company, was most recently North Carolina sales manager for Ashe Brick Co.

W. F. SCHULTEN

J. E. HENDERSON

Personnel changes were recently announced by Consolidation (formerly Pittsburgh) Coal Co. **James M. Knowles,** vice president of the company and president of Fairmont Supply Co., retired in January after 32 years of service. **Walter F. Schulten,** vice president, has been assigned responsibility for the company's relations with governmental agencies on transportation and related matters. **Jack E. Henderson** has been promoted to general traffic manager. Mr. Knowles joined the company in 1926 as assistant general purchasing agent for all the divisions of Consolidation Coal Co. and became general purchasing agent in 1944. Following the formation of Pittsburgh Consolidated through merger, he was named coordinator of purchases of the parent company in 1946. He was elected vice president in charge of purchases and trade relations in 1951.

Phil Rawding is now southeastern sales supervisor for the mining and construction division, Vascoloy-Ramet Corp. He will be in charge of a new branch office of the company at Asheville, N. C.

B. DeWitt Mitchell has become executive president of Yucca Mining & Petroleum Co. Inc., Albuquerque, N. M. Mr. Mitchell is a geologist and petroleum production engineer with more than 20 years' experience in the banking and investment business, specializing in the oil and mining fields.

J. R. Grizzle is now director of sales of Yuba Mining Div., Yuba Consolidated Industries Inc., San Francisco. Mr. Grizzle came to Yuba in 1957 and has been sales manager of Yuba Manufacturing Div. A graduate of the University of California School

personals

continued

of Mines, he has had many years of diversified experience in mining including being superintendent of Liberty Hills Gold Mines Ltd., factory representative for Byron Jackson, superintendent of machinery installations for California Shipbuilding Corp., and European sales manager of Cardwell Manufacturing Co.

Sydney Steele is now director of public relations for Atlas Powder Co., Wilmington, Del. Acting director of the department since September, Dr. Steele joined Atlas in 1950 as manager of market research. He has been director of the planning staff and industrial assistant to the senior vice president in charge of Atlas' Chemicals Div.

Arne E. Matala, who has been with U. S. Steel's Oliver Iron Mining Div. since 1917, has been made superintendent of industrial relations for the Division's eastern district.

Roger Jeanty, vice president of the Pyrites Co. Inc., Wilmington, Del., a subsidiary of Rio Tinto, has been made executive assistant to the president of Rio Tinto Mining Co. of Canada.

Wilber C. Manning, assistant director of sales in Atlas Powder Co.'s Explosives Div., retired as of April 1st. He had been with the company since 1930, and previously worked for the Peerless Union Explosives Co. of Wilkes-Barre, Pa., before that company was acquired by Atlas.

F. KAMAN

A. B. CHAVEZ

Frank Kaman has been appointed chief air tool engineer of Thor Power Tool Co.'s Aurora Works. He was formerly chief mechanical engineer.

Albert B. Chavez has been named resident sales engineer for the International Dept. of Western Machinery Co. His headquarters will be in El Paso, Texas.

H. C. Birkhead has been promoted from general manager of agency sales to general sales manager of Island Creek Coal Sales Co. of Huntington, W. Va.

Lyman G. Bonner has been promoted to the newly created position of director of development of the Explosives Dept. of Hercules Powder Co., Wilmington, Del. **L. G. Maury** succeeds Dr. Bonner as manager of the Explosives Research Div. and High Pressure Laboratory.

William E. Bertholf, II, has been appointed economic geologist on the staff of the State Bureau of Mines and Mineral Resources, a division of the New Mexico Inst. of Mining & Technology, Socorro, N. M. He had been a practicing consultant in Chicago and Crystal Falls, Mich.

Charles Grosso, formerly assistant foreman for National Potash Co., has been promoted to mine superintendent.

Francis L. Pierson has been promoted from senior geologist to chief geologist of United States Potash Co. a division of United States Borax and Chemical Co.

Henry G. Schmidt, president of the North American Coal Corp., Cleveland, has been appointed operator-trustee on the board of trustees of the United Mine Workers of America Welfare and Retirement Fund. He

succeeds **Charles A. Owen** of New York, who served on the board from 1950 until his death last fall.

Albert R. Cook, formerly sales development engineer for Northern Aluminium Co. Ltd., of Oxfordshire, England, has been made market development engineer for the American Zinc Inst. Inc., New York.

Robert L. Williams has been promoted to advertising manager of Gardner-Denver Co. of Quincy, Ill. He was formerly assistant advertising manager for the company's Industrial Products Div.

A. R. COOK

R. L. WILLIAMS

M. W. Reed, formerly executive vice president-engineering and raw materials, has been named executive vice president-international and raw materials, of U. S. Steel Corp. This change of responsibilities involves the consolidation of corporation interests in international commercial matters into a new International and Raw Materials Dept. It is recognition of the close relationship between research and facility planning, as well as an association between current raw materials operations and foreign markets.

Arthur W. Goring, formerly manager of the Uranium Div. of the New Idria Mining & Chemical Co. at the Grand Junction, Colo., plant, is now secretary-treasurer of the same company. He has been transferred to Idria, Calif.

B. F. Webster, Jr., metallurgist for the Consolidated Coppermines Corp. for 15 years, has retired. He is living in Auburn, Calif., and will do some consulting work.

D. P. R. Cassad has been elected president of the Institution of Engineers (India) for the year 1957-1958.

John Bratton has become plant engineer of the Big Rock Stone & Material Co. of Little Rock, Ark. He was formerly a junior engineer with the Minnesota Mining & Manufacturing Co.

The Kennecott Copper Corp.'s Ray Mines Div. has announced a new line of organization for production and maintenance operations. **Ray W. Ballmer**, formerly assistant pit superintendent, has been made production superintendent, and **A. L. Dickerson**, former assistant mechanical superintendent, is now maintenance superintendent. New scheduling foremen for the departments

personals

continued

will be **F. R. Sargent,** Production Dept., and **C. K. Vance,** Maintenance Dept. In the Maintenance Dept., **H. H. Hubbard** has been named general shop foreman, and **Ernie Hughes** truck, dozer, and grader repair foreman.

Armand L. Labbe has joined the staff of the Industrial Fabrics Div. of Albany Felt Co., Albany, as industrial consultant on problems concerning smoke and dust control. Mr. Labbe recently retired from his former position as metallurgist with American Smelting & Refining Co., after serving with that firm for 45 years.

Theodore K. Feyder, formerly sales engineer for Mine Safety Appliances Co. in the Minneapolis district, has been transferred to the Pittsburgh district sales office in a similar capacity. **Darrell E. Albert** has been appointed product line manager for respirators and gas masks. He was formerly sales engineer in Birmingham.

A. L. LABBE

R. G. BATES

Ralph G. Bates has been promoted to general sales manager of Kaiser Engineers, a division of Henry J. Kaiser Co. He was formerly development engineer.

During a business session of the Colorado Mining Assn. held on February 6, the following officers were elected: president, **Max W. Bowen** of Colorado Springs; first vice president, **W. E. Burleson** of Salida; second vice president, **D. W. Viles** of Durango; third vice president, **Frank Coolbaugh** of Golden and Climax; fourth vice president, **J. Paul Harrison** of Denver; fifth vice president, **J. F. Brenton** of Grand Junction; treasurer, **H. W. C. Promel** of Grand Junction; executive vice president, **Robert S. Palmer**; and secretary, **Thelma A. Abel.**

Dale I. Hayes has been named vice president and general manager of The Hidden Splendor Mining Co. of Salt Lake City. Previously Mr. Hayes was associated with the American Zinc, Lead and Smelting Co. as assistant to the president.

Peter M. Bell has taken a temporary leave of absence from the Aluminum Co. of America to continue his studies in geology at the University of Cincinnati. He expects to return to Alcoa by 1959.

The Montana Bureau of Mines and Geology has received copies of a booklet by **Koehler S. Stout** that was translated into Spanish, and has granted permission for the translation of another booklet by Professor Stout. Translations of these booklets, *Operating Ideas for Small Mines* and *Practical Guide for Prospectors and Small Mine Operators in Montana* represent the first time requests of this kind were received by the Bureau from a foreign country. Professor Stout is on the faculty of the Montana School of Mines.

Victor M. Morales is now production supervisor of the American Smelting & Refining Co. in Parral, Mexico.

Wallace A. O'Brien, a member of the geological department of The Anaconda Co., has been promoted to mines geologist. He succeeds **Charles C. Goddard, Jr.,** who has been advanced to geologist in charge of the company's Butte, Mont., mines.

Leigh M. Jones, formerly manager of operations at the Denver office of Western Machinery Co., has been named general manager of the Industrial Sales Div.

The Goodman Mfg. Co. has announced the following changes in personnel: **L. S. Ahlen,** district manager at Terre Haute, Ind., has been promoted to assistant sales manager for mining machinery, and **W. H. Carson,** district manager at Huntington, W. Va., to assistant sales manager for machinery supply parts. Both have been transferred to the company's main office in Chicago. **J. C. Cosgrove** has been appointed acting district manager at Huntington, W. Va.

Darrell Gardner has been appointed general manager of Magma Copper Co. He will be in charge of the Superior, Ariz., operations of the company.

John Richards, a trainee with the Climax Molybdenum Co., has been promoted to shift boss.

L. M. JONES

J. F. HENDERSON

J. Frank Henderson, formerly plant superintendent for Southwest Potash Corp., has joined Kaiser Engineers as a development engineer in the minerals division.

Dr. and Mrs. Bert S. Butler of Tucson have presented $15,000 to the University of Arizona to set up a scholarship fund for graduate work in geology. Dr. Butler was head of the University's department of geology from 1931 to 1948.

Norman A. Moberg has been appointed director of mineral development for U. S. Steel's Oliver Iron Mining Div. He succeeds Lloyd J. Severson. Mr. Moberg was formerly manager of Oliver's mining engineering department.

George A. Scholey, formerly ventilation engineer of the Miami Copper Co., Miami, Ariz., is now block caving development engineer for Philex Mining Corp. at Baguio City in the Philippines.

Clayton G. Ball, D. J. Kachik, and **Paul Eyrich** of the Paul Weir Co., Chicago, have arrived in South Vietnam to prepare an economic and engineering report on the feasibility of developing a coal field at Nong Son in the northern sector.

George H. Deike, Sr., chairman of the board of directors of the Mine

personals

continued

Safety Appliances Co., Pittsburgh, was guest of honor at a dinner sponsored by the Pennsylvania State Lions of Allegheny County. This group is the local alumni organization of Pennsylvania State University, of which Mr. Deike is president emeritus of the board of trustees.

Karl R. Fleischman, formerly mining engineer with the Fiji government, is now a consulting mining and geological engineer with headquarters at Suva, Fiji.

Guido del Castillo, formerly engineer of mines at the graduate school, Colorado School of Mines, has become efficiency engineer of the Compania de Minas del Peru at Puno, Peru.

W. F. Morton has been promoted to mill superintendent of the Chilete Unit of the Northern Peru Mining Corp. He was formerly assistant mill superintendent of the company's Quiruvilca Unit.

The Utah Copper Div. of the Kennecott Copper Corp. has announced the following organizational and title changes: a quality control engineer, not yet named, will head a newly established division department of quality control, and will be responsible to **J. C. Landenberger, Jr.,** general superintendent of operations. Assistant mine superintendents **R. F. Gough** and **J. A. Norden, Jr.,** are now operations superintendent and maintenance superintendent, respectively. These are title changes to define more accurately their duties, which will remain the same. **T. J. Hubbard** and **C. G. Quigley,** superintendents of the Magma and Arthur Mills, respectively, will be responsible exclusively for production. At the refinery, **Karl K. Koropp,** assistant superintendent, will become operations superintendent, and **Roland F. Johnson,** master mechanic, will become maintenance superintendent.

R. Rex Hartup has been appointed Prestress planning engineer for the Leschen Wire Rope Division of H. K. Porter Co. Inc.

J. R. Hall has been promoted to property superintendent of the International Minerals & Chemical Corp., Chicago. It is the responsibility of his comparatively new department to develop and manage the company's land holdings so that income other than mining can be obtained from the properties.

Donald G. Fisher is now geologist for Mineracao Wahchang S. A.'s new Barra Verde mine in Brazil. He was formerly geologist for the Wah Chang Mining Corp.'s Black Rock Mine.

Geza Kisvarsanyi has been transferred to the Bear Creek Mining Co.'s plant at Aurora, Minn., from that company's Rolla, Mo., location. Mr. Kisvarsanyi was formerly assistant professor of geology at the University of Budapest, Hungary, and was also head geologist and director of ore mining at Budapest. He arrived in the United States in January 1957 and began work as an exploration geologist with the Bear Creek Mining Co. in March 1957.

William T. Larsen, formerly mill engineer for The New Jersey Zinc Co., has been transferred to the Texas-Zinc Minerals Corp. as mill engineer.

Alan W. Popp is now assistant to the manager of exploration and mining, American Cyanamid Co., and is working on the evaluation of titanium deposits in eastern United States. Mr. Popp was formerly project geologist with the Heavy Minerals Co.

Vaughn R. Knapp has returned to the Hanna Iron Ore Div. of National Steel, Crosby, Minn., as mining engineer after his discharge from military service.

George Radomsky, formerly staff assistant-manager of the Intermountain Chemical Co., Green River, Wyo., has become industrial engineer for the U. S. Steel Corp. at Lynch, Ky.

H. W. Davis has become geological engineer for The New Jersey Zinc Co. at Harrisburg, Ill. He was formerly geologist of the Piquette Mining & Milling Co., Platteville, Wis.

John Semmens, formerly with Cerro de Pasco Corp. in Peru as mine superintendent, is now assistant mine superintendent for the San Francisco Mines of Mexico Ltd., San Francisco del Oro, Mexico.

J. H. Ashley, assistant managing director of The Fresnillo Co. of Mexico City for 31 years, is now with the same firm on a consulting basis.

Arnold J. Carlson, chief chemist for Climax Molybdenum Co. for two years, now holds the same position for Erie Mining Co., Hoyt Lakes, Minn.

S. Broersma is now plant superintendent for Eldorado Mining and Refining Ltd. He was formerly in charge of the Planning Dept. of M. J. Boylen Engineering Offices.

B. B. Greenlee, formerly general manager of the Resurrection Mining Co. of Leadville, Colo., is now with the Utah Construction Co., Palo Alto, Calif.

L. H. Lange, consulting metallurgist for The Galigher Co., has left for Australia after which he will proceed to the Philippine Islands and will complete his tour by returning to Salt Lake City via Hong Kong and Tokyo. **R. O. Huch** has left for Africa as a metallurgist for Galigher.

Richard L. Sayrs who had been superintendent for the New Jersey Zinc Co., is now a project engineer for Harrison Construction Co., Alcoa, Tenn.

W. D. Carter is working under a two-year contract with the Geology Mission of the International Cooperation Administration of the U. S. Dept. of State as a mining geologist in Santiago, Chile. Mr. Carter most recently was associated with the U. S. Geology Survey in Grand Junction, Colo., as a geologist.

Arthur L. Keats is now assistant chief superintendent of the research and development branch of the South Australian Dept. of Mines and is located in West Thebarton, Australia. He had been chief metallurgist for North Broken Hill Ltd., Broken Hill, New South Wales. Mr. Keats had made extensive tours of the U. S. and Canada in 1947 and 1956.

John M. McAnerney is now general engineer for the U. S. Army, Corps of Engineers, in the Snow, Ice, and Permafrost Research Establishment.

personals

continued

He is connected with the Photo Interpretation Research Branch and is located in Wilmette, Ill. Mr. McAnerney had been engineer for Metcalf and Eddy, engineers in Anchorage, Alaska. This company, through its Anchorage field office, engineered the construction of Western Electric Co.'s microwave communication network over Alaska.

J. C. Nixon returned to Australia from England in October and is now group research metallurgist for Consolidated Zinc Pty. Ltd., Melbourne. While in England, he had been manager of the Anzin Development Laboratory of Anzin Ltd., Avonmouth.

Richard C. Anderson has been promoted to the position of mine superintendent of the Fresnillo Mine, the Fresnillo Co., Fresnillo, Zacatecas, Mexico.

J. C. Zemp has been transferred from the head office of Joy Manufacturing Co. to Lauzanne, Switzerland, where he will be Southeast European representative.

W. M. KIRKPATRICK

C. CAVANAGH

Curran Cavanagh has been elected president of the Fairmont Supply Co. He had been a vice president of the company since 1947.

Ralph H. King has been appointed geologist and technical editor of the State Geological Survey of Kansas and assistant professor of geology at the University of Kansas, Lawrence. A graduate of the University in 1956 with a Ph.D. degree in geology, he had been a geologist with the U. S. Geological Survey, Ground-Water Branch, Lawrence, and most recently a geologist with the USGS Div. of Stratigraphy. During the 1958 spring term, Dr. King will teach a course in paleontology. Prior to joining USGS in 1941, he had been on the editorial staff of *Petroleum Engineer* in Dallas.

William M. Kirkpatrick has been appointed western general counsel of The Anaconda Co., succeeding **James T. Finlen** who resigned to make his home in Florida. A native of Butte, and a graduate of Georgetown University, Mr. Kirkpatrick was legal counsel for The Anaconda Co. at its Butte offices from 1937 to 1940. He then served as Chicago counsel for the company. Following World War II when he served with the U. S. Navy, Mr. Kirkpatrick returned to Butte as a legal counsel for the company.

Grove A. Rathbun, Jr., has taken a leave of absence from his job as mining engineer with the Oliver Iron Mining Div. of U. S. Steel to work for a master's degree in mining engineering at the University of California.

R. A. Teichman, Jr., formerly chief geologist with A. B. Ruddock, retains the same title in his new job with the Pennsylvania Railroad Co. He is directing the railroad's mineral exploration and development program.

Michael Bikerman has become an instructor at Boise Junior College. He was formerly an assayer for Holly Minerals Corp.'s Cinnabar Mine.

Michael V. Anthony who had been engineering geologist with the U. S. Army Snow, Ice, & Permafrost Research Establishment at Wilmette, Ill., is now general engineer with the Military Engineering Dept., U. S. Army Research & Development Laboratories, Belvoir, Va.

Philip Donnerstag has been promoted to supervisor of exploration and development at Climax Uranium Co. He was formerly a geologist with the same company.

Joseph A. Williams has retired and is now living in Escondido, Calif. Prior to his retirement Mr. Williams was with the Alaska Juneau Gold Mining Co. for 35 years, first as an engineer and then as manager.

R. J. Beggs has been promoted to manager of Kerr-Addison Gold Mines Ltd. Previously he had been assistant manager.


C. E. WEED


C. M. BRINCKERHOFF

New officers were elected at the recent directors meeting of The Anaconda Co. **Clyde E. Weed** is now chairman of the board and chief executive officer, succeeding the late Roy H. Glover who died in March. To succeed Mr. Weed as president, the board chose **Charles M. Brinckerhoff** who was also elected director and president of the Anaconda subsidiaries Chile Copper Co., Chile Exploration Co., and Andes Copper Mining Co. **C. Jay Parkinson** was elected vice president. **Norbert F. Koepel** was elected vice president of Chile Exploration and Andes Copper Mining. **Richard S. Newlin** was elected a director of Greene Cananea Copper Co., Chile Copper, Chile Exploration, and Andes Copper. Mr. Weed, who became general manager of mines for Anaconda in 1938, was recipient in 1951 of the AIME William Lawrence Saunders Medal. Mr. Brinckerhoff, who had been executive vice president prior to his new appointment, joined Anaconda in 1935 as assistant mine superintendent for Andes Copper Mining Co. C. Jay Parkinson is general counsel for Anaconda. Mr. Koepel joined Anaconda in 1918 after graduation from Michigan College of Mines & Technology and had been assistant to the vice president of Chile Exploration and Andes Copper prior to his new assignment. Mr. Newlin is vice president in charge of operations for Anaconda.


C. J. PARKINSON


N. F. KOEPEL

G. B. O'Malley has been awarded the Australasian Institute of Mining and Metallurgy Medal for 1957 in recognition of his services to the Institute and to the mining and metallurgical industries. Mr. O'Malley joined the Australian organization of American Cyanamid Co. in 1939, and in 1940 became technical representative for Australia and the Far East for the mining and metallurgical interests of American Cyanamid and its associates. Since 1957, when Cyanamid Australia Pty. Ltd. was established as the Australian unit of the Cyanamid group, Mr. O'Malley has been a director of the company. In addition, he has served as a member of the faculty of engineering of the University of Melbourne, and with advisory and controlling committees associated with mining and metallurgical education and research. Mr. O'Malley joined the Australasian Institute of Mining and Metallurgy in 1927, and has been a member of its council since 1940.

G. B. O'MALLEY
1957 Medal
Winner
Australasian
Inst. of Mining
and Metallurgy

Glen A. Miller, geologist with the U. S. Geological Survey, has been transferred to Santa Barbara, Calif.

Obituaries

Roy H. Glover

An Appreciation By
Clyde E. Weed

It is with regret that I have to record the death, on Mar. 31, 1958, of Roy H. Glover, (Member 1948), chairman of the board of The Anaconda Co., with whom I have been associated for many years.

He was born in Goldendale, Wash., July 15, 1890. His father died leaving his son as sole support of his mother at the age of 15. He received his early education in Goldendale and later attended school at Portland and earned his law degree at the University of Oregon. In 1910, he married Helen Henderson, who survives him. Upon graduation in 1915, Mr. Glover practiced law until he enlisted in the Army. After his overseas duty in the Army and his discharge in 1919 as a sergeant, he entered the service of Great Northern Railway Co. in its legal department in Great Falls, Mont., where he combined his duties with the Railway with those of a growing law practice. He was a member of the firm of Weir, Clift, Glover & Bennett from 1919 to 1936, and a member of Cooper, Stephenson & Glover from 1936 to 1943. Some of his clients were The Anaconda Co., Montana Power Co., Great Northern Railway Co., and the Chicago, Milwaukee, St. Paul Railway Co.

In 1943, he joined The Anaconda Co. to devote his energies to the production of metals for the war effort. Two years after moving to Butte, he became western general counsel and in 1951 Mr. Glover became vice president and general counsel. His rise to the chairmanship in 1955 recorded an advance rare in American industry, for in the space of 12 years he advanced from counsel to chief executive of this corporation.

Mr. Glover brought to the chairmanship of The Anaconda Co. a keen interest in human affairs and a broad understanding of the importance of nonferrous metals in the economic structure of the free world. During his term of office, the Chilean Government enacted the new Chilean Copper law which has received wide approbation as a sound basis for the Chilean fiscal system. Recognition of the service rendered as an unofficial ambassador of good will is evidenced by the high honor bestowed Apr. 6, 1955, when President Ibanez awarded him the rank of Knight Commander, Order of Merit of Bernardo O'Higgins, the highest Chilean decoration which can be bestowed upon a foreigner.

On Feb. 7, 1956 he became an associate member of the Inst. of Political and Administrative Sciences, University of Chile, a distinction which identified him with cultural endeavors of Chile. It was the only time in the history of the University that a foreigner was so honored.

On Jan. 2, 1956, Senator Mansfield of Montana announced that Mr. Glover had been named Montana's *Man of the Year* for 1955. He was chosen from more than a dozen men in the fields of politics, industry, education, and other activities in a poll conducted by the United Press.

In addition to his directorships in The Anaconda Co. and its subsidiaries, Mr. Glover was a director of The First National City Bank of New York and the First Bank Stock Corp. of Minneapolis. He was a member of American and Montana Bar Assns., Federal Power Bar Assn., National Industrial Conference Board, and Academy of Political Science, in addition to AIME. He held an honorary degree, LL.D., from the Montana School of Mines (1957).

Louis M. Allen, Jr. (Member 1916), died on Feb. 12, 1957. A native of New York, where he was born in 1886, Mr. Allen attended the Colorado School of Mines. He began his professional career as a furnace man at the U.S. Metals Refining Co., Chrome, N.J., in 1907. In the following year he went to the west coast. During this time he was also sent to Mexico as assistant engineer in examination work, while employed by Frank A. Keitte of Los Angeles. In 1929 Mr. Allen returned to Mexico as general superintendent for Negociacion Minera de San Rafael y Anexas. He remained in Mexico for many years, working as general superintendent or acting general manager for gold, silver, and copper mines. In 1938 he became general manager for the Compania Minera del Cubo, S.A.

Walter S. Bourlier (Member 1923) died in December 1957. Born in South Mexico, N.Y., Mr. Bourlier graduated from Syracuse University in 1905. The major part of his professional career was spent as chief engineer of mines for Bethlehem Steel Co., Bethlehem, Pa., a position he began in 1914. Previously Mr. Bourlier had spent seven years at General Electric Co. He also held the position of general manager of Southern Cambria Railway, Johnstown, Pa.

Jack E. Chieslar (Member 1955) died in November 1957. A native of Sheridan, Wyo., in 1934, he was a graduate of the South Dakota School of Mines and Technology, where he was awarded his bachelor's degree in mining in June 1957.

Edward J. Fearing (Member 1947) died on Feb. 18, 1958 in Minneapolis where he had been living since his retirement from the position of general superintendent of iron mining for Pickands Mather & Co., Hibbing, Minn. Mr. Fearing was born in Little Falls, Minn., in 1893, and was graduated from the School of Mines & Metallurgy, University of Minnesota in 1917, with a degree in mining engineering. Following two years of World War I military service, Mr. Fearing began his professional career as engineer with John A. Savage & Co., Duluth. Except for one year as pit foreman, he worked as a mine superintendent until 1943, first for John Savage and, for the last ten years, with Pickands Mather & Co. In 1943 Mr. Fearing became general superintendent, Eastern Mesabi district, a position he held until he became general superintendent of iron mines, Hibbing district, Mesabi Range.

W. Sturgis Macomber (Member 1953) died on Aug. 1, 1957. A native of New York, in 1913, Mr. Macomber attended the New York Inst. of Finance and took a course in metallurgy at Brooklyn Polytechnic Inst. Mr. Macomber was connected with the investment banking aspect of the mining field for many years as mining and petroleum security analyst for the investment firm of Reynolds & Co. He began his professional career with Frazier Jelke & Co., members of the New York

Stock Exchange, then worked for a year with the Electric Boat Co., Bayonne, N.J. In 1941 he joined Reynolds & Co. where, two years later, he began to specialize in mining and petroleum securities.

Fred H. Moffit (Member 1918) died on Jan. 22, 1958. For most of his professional career Mr. Moffit was a geologist with the U. S. Geological Survey in the Div. of Alaskan Mineral Resources. Born in 1874 in Princeville, Ill., Mr. Moffit received his bachelor's degree from Williams College in 1895 and his master's degree from Lafayette College in 1899. He also attended Columbia University. Upon graduating from Lafayette, Mr. Moffit spent three years there as an instructor in mathematics and graphics, Mining Engineering Dept. His association with the USGS began while he was attending Lafayette College and continued through his years as an instructor there. During most of that time he spent his summers as a field assistant with the USGS. Upon leaving Columbia University in 1903, Mr. Moffit rejoined the USGS, first as assistant geologist and then as geologist. During that time he spent over 15 years in Alaska, and published many papers on the geology and mineral resources of that country. In 1917 he was temporarily detailed to the Topographic Branch, USGS, to help in developing a method of mapping by the use of aerial photography. Mr. Moffit retired in 1952.

Charles Raymond Stahl (Member 1914) died Dec. 24, 1957. Mr. Stahl was active in the coal industry for 48 years, mostly with Eastern Gas & Fuel Assoc. and its predecessors. Born in Wilkes-Barre, Pa., in 1880, Mr. Stahl received his B.S. in electrical engineering at Pennsylvania State College. He began his career as a transitman with the Mobile, New Orleans & Chicago Railway in 1901, and continued working on various railroads, either full time or during summer vacations, until his graduation from college in 1908. His association with the coal industry began in the following year, when he went to West Virginia to work for the E. E. White Coal Co. as assistant engineer. He became chief engineer in 1911 and assistant general manager in 1917. In 1925, when the company was taken over by the Castner, Curran, and Bullitt Smokeless Coal Co., Mr. Stahl was made division superintendent. He became general manager of the CC&B division when Eastern Gas & Fuel Assoc. purchased the operations in 1927. In 1944 he became assistant to the vice president in charge of accident prevention and labor relations. Mr. Stahl was later appointed labor relations manager. He retired from that position in 1952.

Clinton M. Young (Member 1909) died Oct. 14, 1957. Born in Hiram, Ohio, in 1876, Mr. Young was graduated from Hiram College in 1898 and received his B.S. in mining engineering and his B.S.E.M. from the Case School of Applied Science. The major portion of Mr. Young's career was spent in college teaching. From 1906 to 1914 he was associate professor of mining engineering at the University of Kansas. He gave up teaching for a year to become specialist in mining engineering, U. S. Engineer Office, Pittsburgh, and later to be editor of *Colliery Engineer* and associate editor of *Coal Age*. In 1915 he returned to the academic field as associate professor of mining research, University of Illinois. Four years later he became professor of mining engineering at the University of Kansas, and in 1939 he was named professor of mining and metallurgical engineering at the same school.

Wilbur H. Grant (Member 1919) died on Dec. 28, 1957. A consulting mining and geological engineer in San Francisco, Mr. Grant was a native of Aurora, Ill., in 1879, and a graduate of the Michigan College of Mines with an E.M. degree. After a brief period as an instructor in the

department of geology at Michigan College, he went to Arizona where he worked for Mascot Mining Co. in Klondyke and Arizona Commercial Copper Co. in Globe. Before opening his San Francisco consulting office in 1914, Mr. Grant had been associated with Spurr & Cox Inc. and American Smelting & Refining Co., both in New York.

Necrology

Date Elected	Name	Date of Death
1928	Alexander Hamilton Bell	Feb. 24, 1958
1953	Lehman E. Broxman	Dec. 23, 1957
1951	Rupert Garrison	May 12, 1957
1948	Roy H. Glover	Mar. 31, 1958
1957	Harrison L. Goodman	Mar. 7, 1958
1916	B. W. Knowles	Nov. 14, 1957
1954	Phillip Maverick, Jr.	Nov. 29, 1957
1953	Leroy A. Palmer	Unknown
1947	Edward C. Schwartz	Feb. 1, 1957
1950	E. H. Stevens	Mar. 26, 1958
1957	O. C. Wilson	July 26, 1957

MEMBERSHIP

Proposed for Membership
Society of Mining Engineers of AIME

Total AIME membership on Apr. 30, 1958, was 29,713; in addition 2,927 Student Members were enrolled.

ADMISSIONS COMMITTEE

E. H. Crabtree, Jr., Chairman; Frank Ayer, Jack Bonardi, Edward G. Fox, J. A. Hagy, F. W. McQuiston, Jr., Pauline Moyd, A. D. Rood, L. P. Warriner.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

Members

Ernest J. Anderson, Duluth
Enoch A. Brown, Jr., Battle Mountain, Nev.
John F. Clouser, Pocatello, Idaho
Ernest M. Colwell, Fallon, Nev.
Donald E. Cooksey, Silver Bay, Minn.
John J. Crowhurst, Fort, Wash.
Raymond E. Dawson, Chicago
Robert C. Dean, Jr., Phillipsburg, N. J.
Frederick T. Fischer, Thorn Hill, Tenn.
Harold W. Flood, Cambridge, Mass.
Borman T. Gilmour, Jos, Nigeria
Ernst P. Hall, Pittsburgh
Clyde S. Huffman, Salt Lake City
Charles W. Kelley, Jr., Grants, N. M.
Attilio Ligasacchi, Rolla, Mo.
Edward O. Mason, Mexico City, Mexico
Rubin W. Matson, Port Chester, N. Y.
Edwin H. Miles, Galena, Ill.
Eduardo Molina A., Siuna via Managua, Nicaragua
Peter A. Morris, Fremont, Ohio
Harry S. Poller, Moab, Utah
Fred L. Shanklin, New York
David L. Springston, Columbus, Ohio
George W. Streepey, Pittsburgh
Randall J. Weege, Grants, N. M.
Francis M. Young, Butte, Mont.

Associate Members

Hermann A. Becker-Fluegel, New York
Giles F. Bush, Salt Lake City
Albert B. Chavez, El Paso, Texas
George J. Dole, St. Louis
Leonard R. Fayle, Las Vegas, Nev.
John H. Foust, Rosemont, Pa.
LeRoy Gunnarson, Anchorage, Alaska
Colin C. Gunner, Freetown, Sierra Leone, British West Africa
Melvin D. Iverson, Salt Lake City
Philip C. Reeves, Chicago
Thomas Wooh, Stamford, Conn.
Robert Zaborowski, Chicago

Junior Members

Charles A. Barber, Lone Star, Texas
Martin O. Brauns, Mullan, Idaho
Stephen Chwastiak, Ottawa
Robert H. Gessner, Victorville, Calif.
Wayne J. Helfrich, West Allis, Wis.
Gregory A. Knapp, Denver
Robert J. Kuehneman, Hanover, Ill.
John W. Waite, Tucson, Ariz.
George K. Williams, Santa Ana, Calif.

CHANGE OF STATUS

Associate to Member

Andrew V. Bailey, Miami, Okla.
Ben B. Chomiak, Santa Barbara, Mexico
A. J. Davidson, Denver
Max C. Hoag, Chisholm, Minn.
Michael J. Horvath, Wharton, N. J.
David L. Kuck, Miama, Ariz.
Harrie W. Mallery, Denver
Federico Martinez, Plant City, Fla.
Robert J. McArdle, Westport, Conn.
Bernard T. McDonald, Anaconda, Mont.
Edwin J. O'Connell, Pedro Valley, Calif.
John D. Pelletier, San Manuel, Ariz.
James W. Peters, Morristown, N. J.
James J. Quinlan, Spokane
Elford H. Roberts, Jr., Wheelwright, Ky.
Charles E. Taylor, Jr., Lebanon, Pa.
John K. Weglo, Onaping, Ont., Canada
Frank E. White, Bartow, Fla.
Robert E. Yourston, Dragerton, Utah

REINSTATEMENTS

Members

Seymour J. Beers, York, S. C.
Clarence G. Dresser, Keokuk, Iowa
D'Arcy R. George, Bedford, Mass.
Spurgeon E. Hyatt, Tate, Ga.
Ciro T. Mundaca, Staten Island, N. Y.
Robert H. Saunders, Fairbanks, Alaska

REINSTATEMENT—CHANGE OF STATUS

Junior to Member

Wilbur A. Haley, Peoria, Ill.
Charles R. Ivey, Mineral Point, Wis.
Howard R. Johnson, Redlands, Calif.
Lyman Moore, Moab, Utah
Edwin M. Weiss, Dunellen, N. J.

Student to Member

Edmund A. Muth, Carson City, Nev.

Student to Associate

Dewey S. Harwood, Jr., Reno, Nev.

Appraisals
Assayers
Chemists
Construction
Consulting
Drilling

Professional Services

Geophysicists
Drilling
Management
Metallurgical
Reports
Valuations

Space limited to AIME members or to companies that have at least one member in their staffs. One inch, $50 per year; half inch, $30 payable in advance.

Alabama

COWIN & COMPANY, INC.
Mining Engineers and Contractors
Shaft & Slope Sinking • Mine Development
Mine Plant Construction
1-18th Street SW,
Birmingham, Ala. Phone 56-5566

KIRK & COWIN
Consulting • Appraisals • Reports
1-18th Street SW,
Birmingham, Ala. Phone 56-5566

Arizona

THEODORE A. DODGE
Consulting Mining Geologist
635 North Third Ave. Tucson, Arizona

JAMES A. HOAGLAND
Consulting Mining Geologist
635 North Third Ave. Tucson, Arizona

CHARLES P. SEEL
Mining Geology
Examinations in Mexico
635 North Third Ave. Tucson, Ariz.

STILL & STILL
Consulting Mining Engineers and Geologists
24 Union Block — Phone 658
P.O. Box 1512
Prescott, Arizona

VOUGHT & CLOETER, LTD.
Diamond Core Drilling Contractors
(Specialists in wireline)
2000 S. Freeway Box 5751
Tucson, Arizona MA 4-5452

Arkansas

RAPHAEL G. KAZMANN
Consulting Ground-Water Engineer
Stuttgart, Arkansas

California

FAIRCHILD AERIAL SURVEYS, INC.
Airborne Magnetometer & Gradiometer Surveys, Topographic Mapping, Aerial Photography, and Photographic Mosaics for Mining Exploration.
224 E. 11th St. Los Angeles
30 Rockefeller Plaza New York

FRANCIS H. FREDERICK
Consulting Mining Geologist
690 Market Street
San Francisco 4, California
Telephone: Sutter 1-1562

ABBOT A. HANKS, Inc.
ASSAYERS-CHEMISTS
Shippers Representatives
624 Sacramento Street
SAN FRANCISCO

JOHN D. HESS
Consulting Ground-Water Geologist
• Investigations • Electrical Logging
• Reports • Drainage Surveys
• Geochemical Studies • Water Supply
Complete Physical-Chemical Laboratory Facilities
EL CENTRO, CALIFORNIA

WARREN L. HOWES
Consultant
Mining & Metallurgical Plants
Research, design, construction, operations
Project Management
Estimates—Appraisals
1305 Hillview Dr., Menlo Park, Calif.
Tel. DAvenport 5-7752

CARLTON D. HULIN
Mining Geology
7 Ardilla Road Orinda, California

JACOBS ASSOCIATES
Consulting Construction Engineers
Specialists in tunnel and shaft work — Estimates — Methods Analyses — Engineering Geology — Designers of hoisting, haulage, materials handling and reduction plants.
503 Market Street, San Francisco 5, Calif.

KELLOGG EXPLORATION COMPANY
Geologists-Geophysicists
Air, Ground Surveys and Interpretation
3301 No. Marengo, Altadena, Calif.
Sycamore 4-1973

KELLOGG KREBS
Mineral Dressing Consultant
564 Market St., San Francisco 4, Calif.

MAC AFEE and COMPANY
Consulting Engineers
MINE EXAMINATION & MILL DESIGN
Exploration • Construction
Operation & Management
CHEMICAL & METALLURGICAL LABORATORY
FOR EXACT QUANTITATIVE FLOWSHEET DATA
3105 Wilshire Boulevard • Los Angeles 5
DUnkirk 8-9674 • CABLE MACAFEE

CLAYTON T. McNEIL, E. M.
Consulting Mining Engineer
832 Bank of America Bldg.
Tel. GArfield 1-2948
SAN FRANCISCO 4, CALIFORNIA

ASSAYS—Complete, accurate, guaranteed. Highest quality spectrographic. Only $5 per sample.
REED ENGINEERING
620-AB So. Inglewood Ave.
Inglewood 1, Calif.

CHARLES H. THURMAN
FLOYD M. BLANCHARD
Consulting Engineers
Bucket & Drag Line Placer Dredges
625 Market St. San Francisco 5, Calif.

Colorado

BALL ASSOCIATES
Oil, Gas and Minerals Consultants
Douglas Ball S. Power Warren
Offices
C. A. Johnson Bldg. Denver, Colo. ALpine 5-4878
1025 Vermont Ave. Washington, D. C. STerling 3-1929

O. W. WALVOORD CO.
Mill-Design and Construction
401 High St. Denver 3, Colo.

Connecticut

JOHN F. MYERS
Consulting Beneficiation Engineer
2 Putnam Hill
Greenwich, Conn.

GODFREY B. WALKER
Metallurgical Consultant
Mineral Dressing & Extractive Metallurgy
Heavy Media a Specialty
33 Ballwood Road, Old Greenwich, Conn.

District of Columbia

JOHN D. MORGAN, JR., E. M., PH. D.
Consultant
Business and Defense Problems in Metals, Minerals, and Fuels
1001 Connecticut Ave., N.W.
Washington 6, D. C.
ME 8-1681

CLOYD M. SMITH
Mining Engineer
Mine Examinations
Ventilation Surveys
Munsey Building Washington 4, D.C.

Florida

HARRY B. CANNON ASSOCIATES
Geologists — Engineers
Exploration Ore Dressing
Specialists in Heavy Minerals
P.O. Box 2432 Lakeland, Florida

ALLEN T. COLE and ASSOCIATES
Consultants — Industrial Minerals
Phosphate, Barite, Heavy Minerals, Industrial Sands
2815 Cleveland Heights Blvd.
Lakeland, Florida
MUtual 9-9351 MUtual 3-9033

Frank M. Murphy & Associates, Inc.
DESIGN & CONSTRUCTION ENGINEERS
Specializing in Material Handling Mining Mineral Beneficiation & Chemical Processing
Wesley M. Houston John C. Yost
J. D. Raulerson, Jr.
Box 271 Bartow, Fla.

Georgia

BLANDFORD C. BURGESS
Registered Professional Engineer
Mining Consultant
Monticello, Georgia

Continued on Page 730

Professional Services

Continued from Page 729

Idaho

6526 Holiday Drive — Phone 4-1925
Boise, Idaho
WARREN R. WAGNER
Geologist
Serving the Mining, Chemical and Construction Industries

Illinois

ALLEN & GARCIA COMPANY
47 Years' Service to the Coal and Salt Industries as Consultants, Constructing Engineers and Managers
Authoritative Reports and Appraisals
332 S. MICHIGAN AVE., CHICAGO
120 WALL ST., NEW YORK CITY

JOHN F. MEISSNER ENGINEERS, INC.
Consulting Engineers
Conveyor Systems — Storage Methods
Crushing Plants — Ship Loading Docks
Materials Handling and Processing Plants
308 W. Washington St. Chicago 6, Ill.

PAUL WEIR COMPANY
Mining Engineers and Geologists
Consultants and Managers
Design and Construction
20 No. Wacker Drive Chicago 6, Ill.

Indiana

DIAMOND CORE DRILLING BY CONTRACT
and world's largest manufacturer
Core and grout hole drilling in coal, metal, and non-metallic deposits, both surface and underground.
JOY MANUFACTURING CO.
Contract Core Drill Division
Michigan City, Indiana

Kansas

DAVID LeCOUNT EVANS
Consultant
Mining Geology — Petroleum Geology
314 Brown Bldg. Wichita, Kansas
Tel.: AMherst 2-8954 or MUrray 3-6437

Kentucky

JAMES M. DANIEL — JAMES J. LEWIS AND ASSOCIATES
Civil and Mining Engineering Consultants
United States and Foreign
860 Porter Place Lexington, Ky.

Massachusetts

RAYMOND B. LADOO
Consulting Engineer—Industrial Minerals
Deposit Location, Exploration, Process Design, Marketing, Economics, Percentage Depletion.
42 Huntington Road Newton 58, Mass.
Phone: (Boston) LAsell 7-1471

H. L. TALBOT
Consulting Metallurgical Engineer
Extraction and Refining of Base Metals
Specializing in Cobalt and Copper
Room 911, 209 Washington Street
Boston 8, Mass.

Minnesota

THERON G. GEROW
MINING CONSULTANT AND ENGINEER
3033 Excelsior Blvd.
Minneapolis 16, Minn.
Telephone: Walnut 2-8828

E. J. LONGYEAR COMPANY
Geological and Mining Consultants
Photogeology
76 South 8th St. .... Minneapolis 2, Minn.
Graybar Bldg. .... New York 17, N. Y.
Colorado Bldg. .... Denver 2, Colo.
Shoreham Bldg. .... Washington 5, D. C.
77 York Street .... Toronto, Ont.
129 Ave. De Champs-Elysees Paris, France
Zeekant 35 .... The Hague, Holland

R. L. LOOFBOUROW *Min. Engr.*
Site Appraisals — Plans — Estimates
and supervision of
Underground Construction — Mining
4032 Queen Ave. So. Minneapolis 10, Minn.

ABE W. MATHEWS ENGINEERING CO.
Iron Ore Concentration Plants
Materials Handling Systems
Design and/or Construction
Hibbing — Minnesota

H. M. PICKERING
Registered Professional Engineer
Mining Consultant
Truck Haulage & Crushing Plants
302 E. 22nd, Hibbing, Minn. AM 3-5153

Missouri

PHILIP L. JONES
Consultant
Mineral Economics & Mineral Dressing
Heavy Media Specialist
405 Miners Bank Bldg. Joplin, Mo.
Tel. MAyfair 3-7161

AMEDEE A. PEUGNET
CONSULTING MINING ENGINEER
Telephone MAIN 1-1431
705 Chestnut St. St. Louis 1, Mo.

Montana

IRVING G. IRVING
Consulting Mining Geologist
Mine Examination and Valuation
Counsel in Development & Exploration
Geological Investigations
507 Silver Bow Block, Butte, Mont.
Phone 2-3445

Nevada

C. P. KEEGEL
Mining and Metallurgical Engineer
Administration — Appraisal
Specializing in Management and Consultation in Latin America
1721 So. 14th St., Las Vegas, Nevada
Telephone DUdley 4-6981

THORP D. SAWYER
Consulting Engineer
Registered in Mining and Civil
414 First National Bank Bldg.
206 North Virginia St. Reno, Nevada

New Jersey

LEDOUX & COMPANY
Chemists — Assayers — Spectroscopists
SHIPPERS REPRESENTATIVES
Mine Examination Analyses
359 Alfred Ave. Teaneck, New Jersey

New York

BEHRE DOLBEAR & COMPANY, INC.
Geological, Mining and Metallurgical Consultants
11 Broadway New York 4, N. Y.

GERAGHTY, MILLER & HICKOK
Consulting Ground-Water Geologists
Evaluation of Ground-Water Supplies
Recommendations for the Solution of Ground-Water Problems
110 East 42nd St. New York 17, N. Y.

KNOWLES ASSOCIATES
Chemical - Metallurgical - Mechanical
ENGINEERS
CHEMICAL METALLURGY
ECONOMIC STUDIES - MILL DESIGN
19 RECTOR ST. NEW YORK (6) N. Y.

LEGGETTE, BRASHEARS & GRAHAM
Consulting Ground-Water Geologists
Water Supply — Salt Water Problems
Dewatering — Investigations
Recharging — Reports
551 Fifth Avenue, New York 17, N. Y.

WILSON T. LUNDY
Consulting Mining Engineer
161 East 42 Street New York 17, N. Y.
Tel: MU 7-8100

ARNOLD H. MILLER INC.
Consulting Engineer
Mine, Mill and Industrial Investigations
Improvement Design and Recommendations
Cable: "ALMIL" Tel. Cortlandt 7-0635
120 Broadway New York 5, N. Y.

O'DONNELL & SCHMIDT
Mining Consultants
165 Broadway — Tel. BArclay 7-6960
New York 6, N. Y. — Cables: EXAMIMINES

LUCIUS PITKIN, INC.
Mineralogists
Assayers—Chemists—Spectroscopists
Shippers' Representatives
PITKIN BLDG., 47 FULTON ST., NEW YORK
Cable Address: Niktip

HARRY J. WOLF
Mining and Consulting Engineer
Examinations—Valuations—Management
One Park Place, New York 7, N. Y.
Cable: MINEWOLF Tel. Rector 2-5307

WORLD MINING CONSULTANTS, INC.
Consulting Mining Engineers and Geologists
220 Broadway, New York 38, N. Y.
Worth 2-2934

North Carolina

HARRY E. LE GRAND
Consulting Ground-Water Geologist
Water Supplies—Mine Drainage
Investigations—Reports
P.O. Box 10602 Raleigh, N. C.

Ohio

B. B. R. DRILLING CO.
National Road West
St. Clairsville, Ohio
Diamond Core Drilling Contractors
Mineral Cores Guaranteed
Foundation Testing

Oregon

E. A. MESSER & ASSOCIATES, INC.
Consulting Mining Engineers • Contract Diamond Core Drilling • Contract Drilling & Blasting • Mineral Surveying & Mapping • Mineral Exploration, Domestic & Foreign
Second & Walnut Sts.
Hillsboro, Oregon Phone 4441

Pennsylvania

NEWELL G. ALFORD
Consulting Mining Engineer
Coal Property Prospecting, Development, Operation and Valuation
Oliver Building Pittsburgh 22, Pa.

EAVENSON, AUCHMUTY & GREENWALD
MINING ENGINEERS
Mine Operation Consultants
Coal Property Valuations
2720 Koppers Bldg. Pittsburgh 19, Pa.

GRAFF ENGINEERING COMPANY
Mining Engineers and Surveyors
39 E. Campbell St. Blairsville, Pa.

ROBERT S. MAYO
Civil Engineer Lancaster, Pa.
Specializing in Concrete Lining of Tunnels, Haulageways and Shafts. Special Equipment for Subaqueous Construction.

J. B. MORROW
COAL CONSULTANT
Oliver Bldg. Pittsburgh, Pa.

PENNSYLVANIA DRILLING COMPANY
Subsurface Explorations. Grouting. Industrial Water Supply. Mineral Prospecting Large Diameter Drilled Shafts.
Reports
1205 Chartiers Ave., Pittsburgh 20, Pa.

SPRAGUE & HENWOOD, Inc.
SCRANTON 2, PA.
Diamond Drill Contractors and Manufacturers
Core borings for testing mineral deposits in any part of the world.

J. W. WOOMER & ASSOCIATES
Consulting Mining Engineers
Modern Mining Systems and Designs
Foreign and Domestic Mining Reports
Henry W. Oliver Bldg., Pittsburgh, Pa.

Tennessee

JAMES A. BARR
Consulting Engineer
Mt. Pleasant, Tennessee

MINERAL DRILLING SERVICE
Mineral Valuations & Surveys
Core Drilling
Box 4134 Chattanooga 5, Tennessee

J. R. THOENEN
Consulting Mining Engineer
Sanford Day Road
Concord, Tennessee

Texas

GUY E. INGERSOLL
Registered Professional Engineer in Texas, Arizona and New Mexico
Mine Examinations and Geological Reports
5505 Timberwolf Drive El Paso, Texas

EXAMINATION—EVALUATION—EXPLORATION
METALLIC AND NONMETALLIC MINERALS
DOMESTIC—FOREIGN
HOWARD G. SCHOENIKE
Consulting Mining Geologist
4039 Turnberry Circle
MOhawk 5-7079 Houston 25, Texas

CONRAD WARD THOMAS
Mining Consulting — U. S. and Foreign
► EXAMINATION ► VALUATION
► EXPLORATION
► DIVERSIFICATION ► FINANCING
Bank of the Southwest Building
Houston, Texas
CApitol 7-5855 Cable "GEOCONS"

Utah

CENTENNIAL DEVELOPMENT CO.
Consulting Mining Engineers and Contractors
Shaft Sinking — Tunnel Driving
Mine Development
Eureka, Utah Phone 560

EAKLAND & OSTERSTOCK
Consulting Mining Geologists
700 Newhouse Bldg.
10 Exchange Place Salt Lake City, Utah
EL 9-6185

FREDERICK W. HANSON
Mining Engineer
Registered Professional Engineer
Surveys—Examinations—Appraisals
Operations
32 So. 13th E., Salt Lake City 2, Utah

PRODUCTION AND MANAGEMENT SPECIALIST
ROGER V. PIERCE
Underground Mining Methods, Cost Cutting Surveys—Production Analysis—Mine Mechanization—Mine Management.
808 Newhouse Bldg. EMPIRE 3-5378
Salt Lake City 4, Utah

SHENON AND FULL
Consulting Mining Geologists
1351 South 2200 East
Salt Lake City 8, Utah
Telephone HUnter 4-7251
Philip J. Shenon Roy P. Full

INDUSTRIAL PLANT DESIGN
Process Development • Estimates
Economic Studies • Plant Layout
F. C. TORKELSON CO.
ENGINEERS
34 E First South • Salt Lake City, Utah

CLYDE H. WILSON
MINING ENGINEER AND GEOLOGIST
Registered Professional Engineer
GEOLOGICAL & GEOPHYSICAL SURVEYS
Mineral Deposits • Petroleum
Ground Water
366 South Fifth East, Salt Lake City 2, Utah

Virginia

THOMPSON & LITTON
Consulting
CIVIL AND MINING ENGINEERS
P.O. Box 517 Wise, Virginia
Surveys Examination Apraisals Design
Tel. Wise 6215

WASHINGTON

R. S. McCLINTOCK DIAMOND DRILL CO.
Spokane, Wash. — Globe, Ariz.
DIAMOND CORE DRILL CONTRACTORS
Diamond Bits — Drilling Accessories

West Virginia

DIAMOND CORE DRILLING CONTRACTORS
Testing Mineral Deposits
Foundation Borings
MOTT CORE DRILLING CO.
Huntington, W. Va.

Wyoming

D. H. ELLIOTT
MINING PHOTOGEOLOGIST
P. O. Box 1007 Casper, Wyoming

Canada

HOWARD M. FOWLER
MINING ENGINEER
P.Eng.: British Columbia & Alaska
408 Rogers Bldg. • Vancouver, B. C.
Telephone: Tatlow 0729
Aircraft — Scintillometer equipped

M. G. SMERCHANSKI
Consulting Mining Geologist
Registered Professional Engineer
411 Childs Bldg. Winnipeg, Manitoba.
Phone: Whitehall 2-6323

LEO H. TIMMINS, P. Eng.
MINING ENGINEER
Examinations - Reports
Financing of Prospects
Suite 700 1980 Sherbrooke, Montreal
Phone Glenview 2376

Mexico

PHILIP B. BROWN
Mexico
Mine Sampling & Economic Reports
Ave de las Quintas No. 20 Tel 307
Parral, Chih., Mexico

WILLIAM J. SHEDWICK, JR.
Mine and Geologic Reports
Mexico and Latin America
New Jersey License 2744-a
P. De La Reforma 20-304 Mexico 1, D.F.

Southern Rhodesia

DAVID C. SHARPSTONE
MINING ENGINEER and GEOLOGIST
Bulawayo So. Rhodesia
Private Bag : Tigg Cables : Minexams

Advertisers Index

ABCs Scale Div. .... *
McDowell Co., Inc.
Edward Howard & Co.

Allis-Chalmers Mfg. Co. 642,643
Construction Machinery Div.
Bert S. Gittins Adv., Inc.

Allis-Chalmers Mfg. Co. 657
Industrial Equipment Div.
Compton Adv. Inc.

American Brattice Cloth Corp. .... *
Tri-State Adv. Co., Inc.

American Cyanamid Co. 660A
James J. McMahon, Inc.

American Manganese Steel Div.
American Brake Shoe Co. .... *
Fuller & Smith & Ross, Inc.

American Steel Foundries .... *
Erwin, Wasey, Ruthrauff & Ryan Inc.

Anaconda Co., The .... *
Kenyon & Eckhardt, Inc.

Arizona Chemical Co. .... *
Hazard Adv. Co.

Athey Products Corp. .... *
Thomson Adv., Inc.

Atlas Copco .... *
Intam Limited

Bin-Dicator Co. .... *
Clark & Bobertz, Inc.

Bixby-Zimmer Engineering Co. .... *
Arbingast, Becht and Assoc., Inc.

Boyles Bros. Drilling Co. 727
W. S. Adamson & Assoc.

Brown, Inc., David 713
The McCarty Co.

Brunner & Lay Inc. .... *
Norman P. Hewitt Adv.

Bucyrus-Erie Co. 648
Bert S. Gittins Adv.

Card Iron Works, C. S. .... *
Mosher-Reimer & Williamson Adv.

Caterpillar Tractor Co. 650, 664, 665
N. W. Ayer & Sons, Inc.

Chain Belt Co. .... *
The Buchen Co.

Colorado Fuel & Iron Corp., The 639
Doyle, Kitchen & McCormick, Inc.

Colorado Iron Works Co. .... *
Walter L. Schump, Adv.

Deister Concentrator Co., Inc. 726
Louis B. Wade, Inc.

Denver Equipment Co. .... Third Cover
Galen E. Broyles Co., Inc.

Denver Fire Clay Co. .... *
Mosher, Reimer & Williamson Adv. Agency

Differential Steel Car Co. 718
Coleman Todd & Assoc.

Dorr-Oliver Inc. 666
G. M. Basford Co.

Eimco Corp., The 668
Matsie Co.

Equipment Engineers Inc. 653
Norton M. Jacobs Adv.

Flexible Steel Lacing Co. .... *
Connor Associates, Inc.

Ford Motor Co. .... *
J. Walter Thompson, Inc.

Galigher Co., The 644
W. S. Adamson & Assoc.

Gardner-Denver Co. 658
The Buchen Co.

Hanks Inc., Abbot A. 728

Hardinge Co., Inc. 721
Adams Associates, Inc.

Hawthorne Inc., Herb J. 660B
Darwin H. Clark Co.

Hercules Powder Co. (Explosives) .... *
Fuller & Smith & Ross, Inc.

Hoffman Bros. Drilling Co. .... *
Hewitt Adv.

Humphreys Engineering Co. .... *
Ed M. Hunter & Co.

Infilco Inc. 725
Willard G. Gregory & Co.

Ingersoll-Rand Co. .... *
Beaumont, Heller & Sperling, Inc.
Marsteller, Rickard, Gebhardt & Reed Inc.

International Nickel Co., The 654
Marschalk & Pratt

Jeffrey Mfg. Co. 649
The Griswold-Eshleman Co.

Joy Mfg. Co. .... *
W. S. Walker Adv. Inc.

Kennedy-Van Saun Mfg. & Engrg. Corp. 660
Robert S. Kampmann Jr.

KW-Dart Truck Co. .... *
Carl Lawson Adv.

Longyear Co., E. J. .... *
Savage-Lewis, Inc.

Mace Co. .... *

Mayo Tunnel & Mine Equipment 724
The Godfrey Agency

Metal Carbides Corp. 719
Meek and Thomas, Inc.

Michigan Chemical Corp. .... *
Wesley Aves & Associates

Mine & Smelter Supply Co. 659
Walter L. Schump, Adv.

Mine Safety Appliances Co. .... Fourth Cover
Ketchum, MacLeod & Grove, Inc.

Nagle Pumps, Inc. .... *
Tri-State Adv. Co., Inc.

National Iron Co. 720
Stewart-Taylor Co.

National Malleable & Steel Castings Co. 704
Palm & Patterson Inc.

Nordberg Mfg. Co. 646, 647
Russell T. Gray, Inc.

Northern Blower Co. 723
Carr Liggett Adv., Inc.

Oldsmobile Div. 663
General Motors Corp.
D. P. Brother & Co.

Phelps Dodge Refining Corp. .... *
The House of J. Hayden Twiss, Inc.

Salem Tool Co. .... *
Meek and Thomas, Inc.

Sanford-Day Iron Works, Inc. .... *
Charles S. Kane Co.

Sharples Corp. .... *
Renner Advertisers

Sheffield Div., ... *
ARMCO Steel Corp.
Potts · Woodbury, Inc.

Smidth & Co., F. L. .... *
The Stuart Co.

Spencer Chemical Co. .... *
Bruce B. Brewer & Co.

Sprague & Henwood, Inc. 652
Anthracite Adv.

Stanco Mfgs. & Sales Inc. .... *
NKR Advertising, Inc.

Stearns-Roger Mfg. Co. 715
Mosher-Reimer-Williamson Adv. Agency, Inc.

Surface Combustion Corp. .... *
Pelletizing Div.
Odiorne Industrial Adv. Inc.

Syntron Company 703
Servad, Inc.

Texas Gulf Sulphur Co. 641
Sanger-Funnell, Inc.

Traylor Engrg. & Mfg. Co. 662
Ritter-Lieberman, Inc.

Tyler Co., W. S. 722

Universal Engineering Corp. .... *
W. D. Lyon Co., Inc.

Vulcan Iron Works .... *
Mosher-Reimer & Williamson Adv.

Western Machinery Co. .... *
Wogrin, Westcott & Frye

Wheel Trueing Tool Co. .... *
Clark & Bobertz, Inc.

Wilfley & Sons, Inc., A. R. .... Second Cover
Ed M. Hunter & Co.

Wilkinson Rubber Linatex, Ltd. .... *
Greenlys Ltd.

Windeler Co., Ltd., George 724
Geo. E. S. Thompson Adv.

* Previous Issues

Leadership in Equipment Engineering
Pays off in Money-Saving Performance in the

DENVER AGITATOR TYPE DISC FILTER

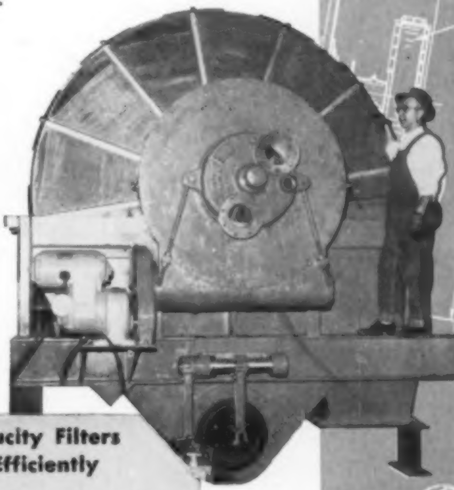
Distinctive design gives proper tank agitation plus maintenance-free operation—eliminates submerged bearings, packing glands and pulp-diluting sealing water.

Simple (patented) DENVER mechanism pulsates, supplies *proper pulp agitation* to keep solids in suspension. Rubber diaphragms seal tank ends, eliminate submerged bearings, packing glands . . . no possible contamination from grease or dilution from sealing water. Lowers maintenance costs.

Uniform particle suspension results in higher filtration capacity, lower moisture content and more uniform, dryer filter cakes—for trouble-free, dependable, PROFITABLE operation.

The DENVER Agitator Type Disc Filter is but one example of DECO leadership in equipment engineering — through functional design, sound research and practical experience.

Agitation mechanism available on all sizes of DENVER Disc Filters (2′, 4′, 6′ and 9′ diameters).



DENVER High Capacity Filters Remove Moisture Efficiently at Low Cost

DENVER Disc Filters provide extremely large filter area for given space. Patented drainage grooves in disc sectors provide positive gravity drainage of filtrates, eliminating blowback and producing dryer filter cake.

Write for Bulletin F9-B5.

"The firm that makes its friends happier, healthier and wealthier"

DENVER EQUIPMENT COMPANY

1400 Seventeenth St. • Denver 17, Colorado

• DENVER • NEW YORK • TORONTO • VANCOUVER • MEXICO, D.F. • LONDON • JOHANNESBURG

DECO ENGINEERS — DENVER EQUIPMENT COMPANY 24 HOUR SERVICE

Complete Mill Equipment